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FOR

1902.

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1902.

NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850,* under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. × $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

ERRATA.

Page xxxi., line 8 from bottom, for "Bugoldi," read "*Bugaldi.*"
,, 75, line 22, for "pigeon," read "*pidgin.*"
,, 75, in the first foot-note, for "[2]," read "[1]"; in the second foot-note for "[3]," read "[2]"; and in the third foot-note, for "[1]," read "[3]."
,, 79, line 30, for "third," read "*first.*"
,, 81, line 2 from bottom, for "first persons," read "*singular.*"
,, 84, line 8, for "waimenguk," read "*walmenguk.*"
,, 87, line 1, for "babannunnu," read "*babannunna.*"
,, 99, line 6, for "nyani," read "*nyaui.*"
,, 99, line 7, from bottom, for "lah," read "*lahr.*"
,, 106, line 5 from bottom, for "dives," read "*dive.*"
,, 138, line 14, for "burrndu," read "*burrandu.*"
,, 145, foot-note, for "Vol. VII.," read "Vol. XVII."
,, 154, line 7, for "bumulyamagiridyu," read "*bumulgawagiridyu.*"
,, 157, foot-note 1, line 1, for "1396," read "1896"; line 3, for p. 471," read "p. 571 and p. 629."
,, 163, line 16, for "badyaldya," read "*badhaldya.*'
,, 165, line 10, for "affimative," read "*affirmative.*"
,, 172, foot-note 1, line 1, for "or," read "*and.*"

PUBLICATIONS.

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vol.	I.	Transactions of the Royal Society, N.S.W.,				1867,	pp. 83,		,,
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I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons, who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

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Titles, &c...

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Address..

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To the

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The Royal Society of N. S. Wales,

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OF THE

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P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

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1900		Jarman, Arthur, A.R.S.M., Demonstrator, University of Sydney.
1902		Jevons, H. Stanley, B.A. *Cantab.*, B Sc. *Lond.*, Sydney University, Glebe.
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1884		‡Jones, Llewellyn Charles Russell, Solicitor, Sydney Chambers, 130 Pitt-street.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College-street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield.
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1878		Joubert, Numa, Hunter's Hill.

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1877		Keep, John, Broughton Hall, Leichhardt.
1887		Kent, Harry C., M.A., Bell's Chambers, 129 Pitt-street.
1898		Kerry, Charles H., J.P., 310 George-street.
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1874		King, The Hon. Philip G., M.L.C., 'Banksia,' William-street, Double Bay.
1896		King, Kelso, 120 Pitt-street.
1892		Kirkcaldie, David, Commissioner, New South Wales Government Railways, Sydney.
1878		Knaggs, Samuei T., M.D. *Aberdeen*, F.R C.S. *Irel.*, 5 Lyons' Terrace, Hyde Park.
1881	P 16	Knibbs, G. H., F.R.A.S., Lecturer in Surveying. University of Sydney; p.r. 'Spottiswoode,' 28 Bland-st., Ashfield. *Vice-President.*
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1878		Kyngdon, F. B.. F.R.M.S. *Lond.*, Deanery Cottage, Bowral.
1874		Lenehan, Henry Alfred, F.R.A.S., Sydney Observatory.
1901		Lindeman, Charles F., Wine Merchant, Jersey Rd., Strathfield.
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 53	Liversidge, Archibald, M A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt. Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France;* Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc. *Tas.;* Roy. Soc., *Queensland;* Senckenberg Institute, *Frankfurt;* Society d' Acclimat., *Mauritius;* Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc. *Vict.*; N. Z. Institute; K. Leop Carol. Acad., *Halle a/s*; Professor of Chemistry in the University of Sydney, The University, Glebe; p.r. 'The Octagon,' St. Mark's Road, Darling Point. *Vice-President.*
1878		Low, Hamilton, 'Lillington,' Cambridge-street, Stanmore.
1884		MacCormick, Alexander, M.D., C.M., *Edin.*, M.R.C.S. *Eng.*, 125 Macquarie-street, North.
1887		MacCulloch, Stanhope H, M.B., C.M. *Edin.*, 24 College-street.
1892		McDonagh, John M., B.A., M.D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*, 178 Macquarie-street, North.
1897		MacDonald, C. A., C.E., 63 Pitt-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1868		MacDonnell, William J., F.R.A.S., 15 Post Office Chambers, Pitt-street.

Elected		
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D P.H. *Camb.*, Hospital for Insane, Callan Park, Rozelle.
1900		McKay, G. A., Federal Public Service Commissioner's Office, Macquarie-st.; p.r. 'Edgeroi,' Clifton Avenue, Burwood.
1891		McKay, R. T., L.S., Sewerage Construction Branch, Public Works Department.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-street, Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.
1876		Mackenzie, Rev. P. F., The Manse, Johnston-st., Annandale.
1880	P 8	McKinney, Hugh Giffin, M.E. Roy. Univ. *Irel.*, M. Inst. C.E., Exchange, 56 Pitt-street; p.r. 'Dilkhusha,' Fuller's Road, Chatswood.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D. *Edin.*, L.R.C.S. *Edin.*, LL.D., Univ. *St. Andrews*, 155 Macquarie-street.
1901		McMaster, Colin J., Chief Commissioner of Western Lands; p.r. 'Monomie,' Longueville.
1901		McMillan, Robert, 129 Macquarie-street.
1894		McMillan, Sir William, 'Logan Brae,' Waverley.
1900		MacTaggart, A. H , D.D.S. *Phil.* U.S.A., King and Phillip-streets.
1899		MacTaggart, J. N. C., B.E. *Syd.*, 16 Lugar-street, Waverley.
1882	P 1	Madsen, Hans. F., 'Hesselmed House,' Queen-st., Newtown.
1883	P 12	Maiden, J. Henry, J.P , F.L.S., Government Botanist and Director, Botanic Gardens, Sydney. *Hon Secretary.*
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1876		Manning, Frederic Norton, M.D. Univ. *St. And.*, M.R.C.S. *Eng.*, L.S.A. *Lond.*, Australian Club.
1869		Mansfield, G. Allen, Martin Chambers, Moore-street.
1897		Marden, John, B.A., M.A., LL.B., Univ. *Melb.*, LL.D. Univ. *Syd.*, Principal, Presbyterian Ladies' College, Sydney.
1875	P 15	Mathews, Robert Hamilton, L.S., Assoc. Mem. Soc. d'Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Roy. Geog. Soc. Aust., Queensland, 'Carcuron,' Hassell-street, Parramatta.
1896	P 5	Merfield, Charles J., F.R.A.S., Railway Construction Branch, Public Works Department; p r. 'Branville,' Green Bank-street, Marrickville.
1887		Miles, George E., L.R C.P. *Lond.*, M.R.C.S. *Eng.*, The Hospital, Rydalmere, near Parramatta.
1889	P 3	Mingaye, John C. H., F.I.C., F.C S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta.
1856	P 7	Moore, Charles, F.R.B.S., C.M.Z.S., Australian Club; p.r. 6 Queen-street, Woollahra.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street.
1875		Moir, James, 58 Margaret-street.
1877	P 1	Morris, William, Fel. Fac. Phys. and Surg. *Glas.*, F.R.M.S. *Lond.*, c/o Mr. W. J. Munro, City Mutual Chambers, Hunter-street.
1877		‡Mullens, Josiah, F.R G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.

Elected		
1887		Munro, William John, B.A., M.B., C.M., M.D. *Edin.*, M.R.C.S. *Eng.*, 213 Macquarie-street; p.r. 'Forest House,' 182 Pyrmont Bridge Road, Forest Lodge.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.
1893		Nangle, James, Architect, Australia-street, Newtown.
1901		Newton, Roland G., 'Northleigh,' Union-street, North Sydney.
1891		‡Noble, Edwald George, 21 Norfolk-street, Paddington.
1873		Norton, The Hon. James, M.L.C., LL.D., Solicitor, 2 O'Connell-street; p.r. 'Ecclesbourne,' Double Bay.
1893		Noyes, Edward, C.E., c/o Messrs. Noyes Bros., 109 Pitt-street.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J., M.D., M.Ch., Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Public Works Department, Cowra.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 197 Liverpool-street, Hyde Park.
1901		Peake, Algernon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. Moss Vale.
1877		Pedley, Perceval R., 227 Macquarie-street.
1877		Perkins, Henry A., c/o Perpetual Trustee Co. Ld., 2 Spring-st.
1899		Peterson, J. T., Associate Sydney Institute of Public Accountants, 85 Womerah Avenue.
1876		Pickburn, Thomas, M.D., C.M. *Aberdeen*, M.R.C.S. *Eng.*, 22 College-street.
1879	P 5	Pittman, Edward F., Assoc. R. S.M., L.S., Under Secretary, Department of Mines.
1899		Plummer, John, 'Northwood,' Lane Cove River, Box 413 G.P.O.
1881		Poate, Frederick, Lands Office, Moree.
1879		Pockley, Thomas F. G., Commercial Bank, Singleton.
1887		Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B.Sc. *Syd.*, Professor of Physics, Sydney University.
1901		Pollitt, J. C. T., Analytical Chemist, Cooperative Wholesale Society Ld., Alexandria, Sydney.
1891		Poole, William, Junr., B.E. *Syd.*, Assoc. M. Inst. C.E., F.G.S., L.S., B. H. Proprietary Co. Ld., Port Pirie, South Australia; p.r. 87 Pitt-street, Redfern.
1896		Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.
1897	P 1	Portus, A. B., Assoc. M. Inst. C.E., Superintendent of Dredges, Public Works Department.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 341 Pitt-street.

Elected		
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden' 14 Queen-street, Woollahra.
1899	P 1	Rae, J. L. C., Manager Sydney Harbour Collieries Ltd.; p.r. 'Strathmore,' Ewenton-street, Balmain.
1900		Ralston, J. T., Solicitor, 86 Pitt-street.
1902		Ramsay, Arthur A., Assistant Chemist, Department of Agriculture, 136 George-street.
1865	P 1	‡Ramsay, Edward P., LL.D. Univ. St. And., F.R.S.E., F.L.S., 8 Palace-street, Petersham.
1901		Raymond, Robert S., Brewer, c/o Messrs. King & Co., Leichhardt
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 40 College-street, Hyde Park.
1870		Renwick, The Hon. Sir Arthur, Knt., M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 295 Elizabeth-street.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1893	P 1	Roberts, W. S. de Lisle, C.E., Sewerage Branch, Public Works Department, 5 Cumberland-street, Dawes Point.
1885		Rolleston, John C., Assoc. M. Inst. C.E., Harbours and Rivers Branch, Public Works Department.
1897		Ronaldson, James Henry, Mining Engineer, 76 Pitt-street.
1892		Rossbach, William, Assoc. M. Inst. C.E., Chief Draftsman, Harbours and Rivers Branch, Public Works Department.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, Hospital for the Insane, Callan Park, Rozelle.
1895		Ross, Colin John, B.Sc., B.E., Assoc. M. Inst. C.E., Borough Engineer, Town Hall, North Sydney.
1895	P 1	Ross, Herbert E., Consulting Engineer and Architect, Equitable Building, George-street.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-st., and Union Club.
1864	P 69	Russell, Henry C., B.A. *Syd.*, C.M.G., F.R.S., F.R.A.S., F. R. Met. Soc., Hon. Memb. Roy. Soc., South Australia, Government Astronomer, Sydney Observatory. *Vice-President.*
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 379*b* George-street; p.r. 'Mahuru,' Milton-street, Ashfield.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street.
1899		Schmidlin, F., Elizabeth-street, Sydney.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street.
1890	P 1	Sellors, R. P., B.A. *Syd.*, F.R.A.S., Trigonometrical Service, Lands Department.
1891		Shaw, Percy William, Assoc. M. Inst. C.E., Resident Engineer for Tramway Construction; p.r. 'Epcombs,' Miller-street, North Sydney.

Elected		
1883	P 3	Shellshear, Walter, M. Inst. C.E., Divisional Engineer, Railway Department, Goulburn.
1900		Simpson, R. C., Technical College, Sydney.
1882		Sinclair, Eric, M.D., C.M. Univ. *Glas.*, Hospital for the Insane, Gladesville.
1893		Sinclair, Russell, M.I. Mech. E., &c., Consulting Engineer, Vickery's Chambers, 82 Pitt-street.
1884		Skirving, Robert Scot, M.B., C.M. *Edin.*, Elizabeth-street, Hyde Park.
1891	P 2	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1893	P 25	Smith, Henry G., F.C.S., Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1899		Smith, R. Greig, D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, 'Otterburn,' Double Bay.
1886		Smith, Walter Alexander, M. Inst. C.E., Roads, Bridges and Sewerage Branch, Public Works Department, N. Sydney.
1896		Smyth, Selwood, Harbours and Rivers Branch, Public Works Department.
1896		Spencer, Walter, M.D. *Brux.*, 13 Edgeware Road, Enmore.
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, J. D., M.R.C.V.S., Government Veterinary Surgeon, Department of Mines and Agriculture; p.r. Cowper-street, Randwick.
1883	P 3	Stuart, T. P. Anderson, M.D., LL.D. Univ. *Edin.*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay.
1901		Süssmilch, C. A., Technical College, Sydney.
1893		‡Taylor, James, B.Sc., A.R.S.M., Adderton Road, Dundas.
1899		Teece, R., F.I.A., F.F.A., Actuary, A.M.P. Society, 87 Pitt-st.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1896		Thom, James Campbell, Solicitor for Railways; p.r. 'Dunoon,' Eurella-street, Burwood.
1896		Thom, John Stuart, Solicitor, Athenæum Chambers, 11 Castlereagh-street; p.r. Wollongong Road, Arncliffe.
1878		Thomas, F. J., Hunter River N.S.N. Co., Sussex-street.
1879		Thomson, Dugald, M.H.R., 'Wyreepi,' Milson's Point.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Camb.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1898		Thow, Sydney, General Manager, The Hercules Gold and Silver Mining Co., Mount Read, Tasmania.
1892		Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh.
1888		Thring, Edward T., F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1894		Tidswell, Frank, M.B., M.Ch., D.P.H., *Camb.*, Health Department, Sydney.
1876		Toohey, The Hon. J. T., M.L.C., 'Moira,' Burwood.
1894		Tooth, Arthur W., Kent Brewery.

Elected		
1873	P 1	Trebeck, Prosper N., J.P., Cowle's Road, Mosman.
1879		Trebeck, P. C., F. R. Met. Soc., 2 O'Connell-street.
1900		Turner, Basil W., A.R.S.M., F.C.S., 14 Castlereagh-street.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'BayView House,' Tempe.
1884		Verde, Capitaine Felice, Ing. Cav., viâ Fazio 2, Spezia, Italy.
1890		Vicars, James, M.C.E., M. Inst. C.E., City Surveyor, Adelaide.
1992		Vickery, George B., 78 Pitt-street.
1876		Voss, Houlton H., J.P., c/o Perpetual Trustee Company Ld., 2 Spring-street.
1898		Wade, Leslie A. B., Assoc. M. Inst. C.E., Department of Public Works.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator J. T., 'Rosemont,' Ocean-street, Woollahra.
1901		Walkom, A. J., A.M.I.E.E., Mem. Elec. Assoc. N.S.W., Electrical Branch, G P.O. Sydney.
1900		Wallach, Bernhard, B.E. *Syd.*, Electrical Engineer, 'Oakwood,' Wardell Road, Dulwich Hill.
1891		Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C E., Engineer-in-Chief, Harbour Trust, Sydney.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1895		Ward, James Wenman, 1 Union Lane off George-street.
1898		Wark, William, 9 Macquarie Place; p.r. Kurrajong Heights.
1902		Warren, Ernest W., B.E., B.A., LL.B., Barrister-at-Law, No. 7, Wentworth Court, Phillip-street.
1877		Warren, William Edward, B.A., M.D., M.Ch, Queen's University *Irel.*, M.D. *Syd.*, 283 Elizabeth-street, Sydney.
1883	P 13	Warren, W. H., Wh. Sc., M. Inst. C.E., Professor of Engineering, University of Sydney. *President.*
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Attorney General's Department.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown.
1897		Webb, Fredk. William, C.M.G., J.P., Clerk of the Legislative Assembly; p.r. 'Normandy,' Darley Road, Manly.
1876		Webster, A. S., c/o Permanent Trustee Co. of N.S. Wales Ld., 17 O'Connell-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L S., *New Zealand*, Borough Engineer, Town Hall, Marrickville.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master, Sydney Grammar School, College-street.
1902		Welsh, David Arthur, Professor of Pathology, Sydney University, Glebe.
1881		‡Wesley, W. H.
1878		Westgarth, G. C., Bond-street; p.r. 52 Elizabeth Bay Road.
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Oeta,' Queen-street, Woollahra.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 213 Macquarie-street.

Elected		
1876		Williams, Percy Edward, Comptroller, Government Savings Bank, Sydney.
1901		Willmot, Thomas, J.P., Toongabbie.
1878		Wilshire, James Thompson, F.L.S., F.R.H.S., J.P., 'Coolooli,' Bennet Road, Neutral Bay.
1879		Wilshire, F. R., P.M., Penrith.
1890		Wilson, James T., M.B., Mast. Surg. Univ. *Edin.*, Professor of Anatomy, University of Sydney
1873		Wood, Harrie, J.P., 10 Bligh-street; p.r. 54 Darlinghurst Road.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1876	P 1	Woolrych, F. B. W., 'Verner,' Grosvenor-street, Croydon.
1902		Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney.
1879		Young, John, 'Kentville,' Johnston-street, Leichhardt.

HONORARY MEMBERS.

Limited to Thirty.

M.—Recipients of the Clarke Medal.

1901		Baker, Sir Benjamin, K.C.M.G., D. Sc., LL.D., F.R.S., etc., 2 Queen Square Place, London, S.W.
1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1875	M	Ellery, Robert L. J., F.R.S., F.R.A.S., c/o Government Astronomer of Victoria, Melbourne.
1887		Foster, Sir Michael, M.D., F.R.S., Professor of Physiology, University of Cambridge.
1875	M	Gregory, The Hon. Augustus Charles, C.M.G., M.L.C., F.R.G.S., Brisbane.
1875	P 1 M	Hector, Sir James, K.C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
1892		Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1888	P 1 M	Hutton, Captain Frederick Wollaston, F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.
1901		Judd, J. W., C.B., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London.
1901		Newcomb, Professor Simon, LL.D., Ph. D., For. Mem. R.S. Lond., United States Navy, Washington.
1894		Spencer, W. Baldwin, M.A., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.
1895		Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Parkstone, Dorset.

Elected	
	OBITUARY 1902.
	Ordinary Members.
1856	Comrie, James
1889	Farr, J. J.
1888	Megginson, Dr. A. M.
1893	Milford, Dr. F.
1882	Moss, Sydney
1875	Thompson, Joseph
1877	Tucker, Dr. G. A.
1874	White, Rev. Dr. James S.
	OBITUARY 1903.
	Ordinary Member.
1882	Milson, James

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE LATE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.

1878 Professor Sir Richard Owen, K.C.B., F.R.S., Hampton Court.

1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.

1880 Professor Huxley, F.R.S., The Royal School of Mines, London. 4 Marlborough Place, Abbey Road, N.W.

1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne.

1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S., Government Botanist, Melbourne.

1884 Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada, Ottawa.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 Professor L. G. De Koninck, M.D., University of Liège, Belgium.

1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.

1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.

1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William Street, Sydney.

1891 Captain Frederick Wollaston Hutton, F.R.S., F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.

1893 Professor Ralph Tate, F.L.S., F.G.S., University, Adelaide, S.A.

1895 Robert Logan Jack, F.G.S., F.R.G.S., Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S., Brisbane.

1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.

1901 Edward John Eyre, Walreddon Manor, Tavistock, Devon, England.

1902 F. Manson Bailey, F.L.S, Colonial Botanist of Queensland, Brisbane.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D, Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

THE PARKS OF SYDNEY; SOME OF THE PROBLEMS OF CONTROL AND MANAGEMENT.

By J. H. MAIDEN,
Director of Botanic Gardens and Domains, Sydney; Officer-in-Charge of the Centennial Park.

[*Read before the Royal Society of N. S. Wales, June 4, 1902.*]

I. GENERAL QUESTIONS.

a. *Introductory.*—Webster says a park is "a piece of ground, in or near a city or town, enclosed and kept for ornament and recreation." This is a condensed dictionary

definition which only needs a little amplification for the purposes of a controller of parks, whatever his functions may be.

The objects of a public park are to assist in securing rest and recreation for the people, to promote their mental and physical health and enjoyment, and no steps should be taken which will limit the realization of these objects.

Anyone who has looked into the matter must have been struck with the paucity of literature referring to parks, at all events as regards Australia, yet the subject is of very high importance. Much has been written in ephemeral literature in regard to the æsthetic and health-giving advantages of parks, but very little, I think, concerning questions involved in their practical working, at all events by those who speak from personal experience of their management. While a controller of parks I have not taken a mechanical view of my duties, and have made it my endeavour that the parks shall not lag behind in the general march of progress which is characteristic of our country and our age. As a public servant I have my limitations of speech, but I express the opinion that, since the parks belong to the people, their enjoyment of them should be catered for to the fullest extent, and there should be no interference with free action on the part of a citizen in his enjoyment of his park other than is necessary in the interests of the citizens as a whole.

b. *Sydney Parks,—how vested and controlled.*—By the courtesy of Mr. H. Curry, Under Secretary for Lands, and of Mr. Henry Selkirk of the same Department, I am enabled to give the following legal and statistical information in regard to the public parks of Sydney. These public grounds are not all controlled in the same way, nor administered under the same Act of Parliament. There are principally three classes:—

First, Areas which are retained under the direct control of the Government and managed by its salaried officers.

In the first class are included the Government Domain, the Botanic Gardens, and the Centennial Park. These are under the supervision of the Director of the Botanic Gardens—a salaried officer of the Chief Secretary's Department.

The Domain and Botanic Gardens are administered under the Crown Lands Act of 1884, and the Regulations governing them are made in pursuance of Section 106 of that Act, 48 Vic. No. 11. The Centennial Park, which adjoins the city on its eastern boundary is administered under the Centenary Celebration Act of 1888, by the Chief Minister.

Second, Areas which have been placed for purposes of management under honorary trustees.

The principal grounds under the control of honorary trustees (individuals) are Hyde Park, Cook Park, Phillip Park, Rushcutters' Bay Park, Victoria Park, and Wentworth Park. The first named (Hyde Park) is the most important of these parks, and its administration, together with Cook and Phillip Parks, comes under the Public Parks Act of 1884, which is administered by the Secretary for Lands. The by-laws for the management of these parks are made by the trustees under that Act, subject to the approval of His Excellency the Governor and the Executive Council.

Third, Areas which have been placed under the control of the Municipal Council of the City of Sydney.

The areas of which the Municipal Council of Sydney are trustees as appointed by His Excellency the Governor are Moore Park (or Sydney Common), Wynyard Park, Prince Alfred Park, Belmore Park, and other minor areas. The Municipal Council are invested with all the powers given by the Public Parks Act for the control of these areas.

In addition to the areas referred to within the foregoing, there is the Sydney Cricket Ground, an area of twelve acres upon which the sum of over £20,000 has in a period of twenty years been expended in improvements. These improvements consist of an oval or enclosure suitable for contests in the games of cricket, football, baseball, lawn tennis, etc., and pavilions and other buildings for the accommodation of spectators. This ground is under the control of honorary trustees, of whom two, the President of the New South Wales Cricket Association, and the Under Secretary of the Department of Lands are *ex officio* trustees.

In the surrounding suburban areas, parks and recreation grounds have also been established, and placed under the control of either the local or Municipal Council or individual trustees as may be deemed fit by His Excellency the Governor with the advice of the Executive Council, on the recommendation of the Secretary for Lands.

There are also on the suburban boundaries of Sydney two parks which are more national than local in their character and purpose. These are the National Park of about 36,000 acres at Port Hacking, fifteen miles south of the city, and Kuring-gai Chase which are administered by the Secretary for Lands under the Crown Lands Act of 1884.

Deeds of grant have in some cases been issued, but it has in later years been found more convenient to vest the control by gazettal of appointment of trustees by His Excellency the Governor as may from time to time be necessary, and to have by-laws and regulations conferring necessary power on such trustees put into force. For the better regulation and control of such Trusts, the Public Trusts Act of 1897 has been enacted, and is now in force.

Dedications of public parks and recreation grounds may be wholly or partly revoked, and the trusts annulled for

any of the reasons stated in Section 105 of the Crown Lands Act of 1884, and the lands thereupon become vested in His Majesty the King, to be dealt with as His Excellency the Governor, with the advice of the Executive Council, may think fit.

By Section 104 of the Crown Lands Act of 1884 a proposed dedication of the Crown Lands for public parks must remain before Parliament for one month without disallowance before it can be gazetted, and a similar provision exists as regards a proposed revocation of any such dedication under Section 105 of the same Act.

The parks of the City of Sydney, except Rushcutters' Bay Park (which was partly resumed and partly reclaimed from Rushcutters' Bay) are areas which have been held in the hands of the Government for such purposes, but in any case where the necessity for a park arises, private lands may be acquired for that purpose under the "Lands for Public Purposes Acquisition Act" of 1880, and the Public Works Act of 1888. The condition precedent in this is, that Parliament shall have appropriated funds to acquire such lands, and His Excellency the Governor, with the advice of the Executive Council, may then issue a proclamation resuming the required land. Upon issue of that proclamation the land becomes vested in some Minister or Officer as Constructing Authority on behalf of His Majesty, and the former owner's interests are converted into a claim for compensation, which is paid upon a satisfactory proof being afforded to the Government, after appraisement if necessary.

A sum of money for the maintenance and improvement of public parks is voted annually by Parliament, and is then distributed in the form of subsidies by the Secretary for Lands. In some cases annual amounts are voted specially for maintenance out of State funds; Hyde, Phillip and

Cook Parks are maintained in this way, and also the National Park; but, in the latter case, the trustees have the right to derive revenues by leases for coal mining and other purposes; in the case of suburban and country parks, it is held that there should also be local contributions for their maintenance.

In addition to the parks and recreation grounds more permanently established by proclamation or dedication, there are also areas in more sparsely settled localities, temporarily reserved, and placed under temporary trustees under the Public Trusts Act, Section 1. These are cases where the conditions are likely to change, and the areas may be required for other purposes, or where it may be that other areas will be more suitable.

It will be understood, from the foregoing, that, although the Government may, except in a few special cases, delegate the management to trustees, yet there is a supreme control still retained; and which may be exercised to the extent of annulling the trust and placing the land again under the direct control of the Government if deemed expedient in the public interest.

In different cities of the world different arrangements are made in regard to control of parks. In London the State and Municipal parks exist under separate administrations. In Paris the great majority of parks are under one head, but in that city Municipal Government is subordinate to State Government. In many British cities, *e.g.*, Glasgow, there is but one administration of parks,—a municipal one.

Sydney is a *capital* city like London or Paris, not simply a municipal city like Glasgow or Manchester. In cities which are the seat of State Government there are always parks and other open spaces directly under the control of

the Government; these open spaces are used for the movements of troops or other public demonstrations or for various State functions. If the executive of a State had not control of some open spaces in its capital, it would at times be inconvenienced and even embarrassed. Such open spaces, although actually within a city boundary, belong as a matter of fact, to the whole of the State, and not to any city in particular. For that reason, as far as Sydney is concerned, there will be State parks and Municipal parks, at all events until such time as New South Wales abrogates its rights as a State.

In Europe there are, in addition, parks which are the property of wealthy people, and to which citizens are admitted under very few restrictions. We have no such parks here, the unoccupied Crown Lands taking their place. In Europe, land being almost entirely owned by private persons, citizens would in many extensive areas be debarred from the health-giving enjoyment of a park were it not for the consideration shown by the landed gentry.

The question of park government is of considerable importance. I am acquainted with many gentlemen who are model trustees, but my view is that Park Trusts are now an anachronism in large cities. I think that parks should be administered by State or Municipal officers or both, as the case may be. They are replaceable for incompetence or malfeasance, and public bodies should interfere with park superintendents as little as possible, if they desire efficient service, the introduction of improvements and the fixation of responsibility. Trustees have performed efficient service in the past, and in many places are indispensable still, but, I reiterate my opinion, that a park superintendent should be a paid and responsible officer, controlled by enlightened superior authority.

c. *Statistical information:—*

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area.			Acquisitions.				Appropriations.		Remarks.
					Nature of Acquisition.	Cost.			Nature of	Date.	
		Ac.	r.	p.		£	s.	d.			
Ashfield ...	Ashfield Park	15	1	19	Crown Purchase ...	5,174	17	3	Proclaimed	18 Dec., 1885	
„ ...	Victoria Square	abt. 0	3	24	Private Dedication						
„ ...	Albert Parade	„ 1	0	0	„ „						
Annandale ..	Reserve Piper Street ..	„ 0	3	28	„ „						
Alexandria ...	Alexandria Park	10	0	0	Resumed 14 Nov., 1882 ..	...			„	18 Oct., 1889	
„ ...	Erskineville Park (part)	14	3	8	„ 20 Oct., 1882 ..	...			„	28 July, 1885	For remainder see
Auburn... ...	Auburn Park	8	0	26	Crown Purchase ...	1,020	6	3	„	26 Mar. 1898	Erskineville
Balmain ...	Easton Park	4	3	17	Resumed 13 Dec., 1889	...			„	9 May, 1890	
„ ...	Gladstone Park	5	0	0¼	„ 22 Sept. 1882...	15,288	9	3	...	28 July, 1885	
„ ...	Birch Grove Park ...	13	2	18	(See remarks) ...	14,043	13	3	...	13 Oct., 1893	7a 3r 2p Cr. Pur.
„ ...	White Bay Rec. Reserve	8	0	17	... ...	...			Dedicated...	9 Sept., 1899	27p 2c R. 4/9/85
„ ...	Punch Park	abt. 2	0	20	Purchased by Municipal						5a 2r 28p 7c
„ ...	Elkington Park	„ 6	0	0	„ „ [Council						Govt. Reclam.
Bankstown ...	Upper Bankstown Park	21	0	0	... ...	...			„	15 Sep., 1891	
„ ...	Reserve at Bankstown ..	5	0	17½	... ...	...			„	23 April 1895	
„ ...	„ George's River...	1	0	4	... ...	...			„	8 Oct., 1898	
„ ...	„ „ ...	8	1	36	... ...	...			„	„	
„ ..	„ Salt Pan Creek .	3	3	20	... ...	...			„	„	
„ ...	„ „ ...	8	0	18	... ...	...			„		
„ ...	Reserve 29582 East Hills	5	1	15	... ...	...			Notified ...	8 July, 1899	
„ ...	„ 31400 George's R.	12	0	0	... ...	...			„	25 Aug., 1900	
Bexley	Seaforth Park	4	0	0¾	Private Dedication ...	...			Conveyed to	Municipal Co	
Botany ...	Banks Meadow Reserve...	10	2	25¼	... ...	...			Dedicated...	12 Mar., 1869	
„ ...	„ „ ...	5	0	0	... ...	...			„	28 June, 1878	
„ ...	Booralee Park	10	0	0	Resumed 23 May, 1883	...			Proclaimed	17 Sept., 1886	
Botany North ...	Nil										
Burwood ...	Burwood Park	15	0	0	Resumed 4 Oct., 1882 ...	15,803	7	8	„	28 July, 1885	
Camperdown ...	Camperdown Park ...	11	1	8½	„ 23 May, 1882...	18,338	3	2	„	„	
„ ...	Victoria Park (University)	23	3	16	... ...	...			„	16 Aug. 1887	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve	Area			Acquisitions.				Appropriations.		Remarks.
					Nature of Acquisition.	Cost.			Nature of.	Date.	
		Ac	r.	p.		£	s.	d.			
Canterbury ...	Canterbury Park ..	19	0	20¾	Crown Purchase ...	5,550	7	7	Proclaimed	13 Oct., 1893	
„ ...	Croydon Park ..	9	0	35	Private Dedication ...	...			„	17 April, 1888	Conveyed to the Crown for Public Park
Concord ...	S. Luke's Park, Longbottom	66	2	15	... ...	...			Dedicated .	8 May, 1886	
„ ..	Reserve Vil. of Longbottom	34	3	30	... ...	...			„	15 June, 1877	
„ ...	Cabarita Park	24	1	0	... ...	...			„	21 April, 1880	
„ ...	Reserve Hen & Chick. Bay	1	3	23	... ...	...			„	„	
„ ...	„ 79 „	3	0	34	... ...	...			Notified ...	29 May, 1882	
„ ..	„ 80 „ port. 106A	5	2	20	... ...	...			„	„	
„ ...	„ 81 port. 64 Cabarita	1	0	30	... ...	...			„	„	
„ ...	„ at Bray's Bay ...	4	1	0	... ...	...			Dedicated ..	17 May, 1895	
Darlington ...	Nil										
Drummoyne ..	Jarrett Park, Birkenhead	1	2	0	Conveyed to the Crown						
„ ...	Reserve at Birkenhead	0	1	34	in exchange for Crown L.						
„ ...	Reserve 31521 Long Cove	0	1	35	Partly by exchange and partly Crown Lands	...			Notified ...	22 Sep., 1900	
Endfield ...	Enfield Park ...	25	3	2½	Resumed 17 July, 1885...	...			Proclaimed	11 Nov., 1893	
Erskineville ..	Erskineville Park (Part) (Macdonaldtown)	abt. 8	0	0	„ 20 Oct., 1882 ..	35,013 (for whole area)	17	7	„	28 July, 1885	For remainder see Alexandria
Fivedock ...	Fivedock Park	21	2	27	Crown Purchase ...	5,000	0	0	„	28 June, 1887	
The Glebe ...	Nil										
Hunter's Hill ...	Boronia Park	62	2	0	... ...	....			„	16 Dec., 1846	
Hurstville ...	Peakhurst Park	112	0	0	... ...	...			„	29 May, 1888	
„ ...	Hurstville Park	7	0	0	„ „ ..	1,050	0	0	„	28 June, 1899	
„ ..	Reserve at Como... ...	11	1	38¾	... ...	...			Dedicated .	23 April, 1895	
Kogarah ...	Kogarah Park	10	2	6	„ „ ...	2,000	0	0	...	...	Not formally appropriated
„ ...	Dover Park, Tom Ugly's P.	4	0	39	... ...	...			„	21 Aug., 1897	
„ ...	Reserve 26444 Kogarah B.	0	0	4¾	... ...	...			Notified ...	4 „	
Lane Cove ...	Reserve at Gore Cove ...	0	0	16	... ...	...			Dedicated...	25 Mar., 1887	
„ ...	„ Tambourine Bay	2	1	4	... ...	...			„	20 Feb., 1874	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area.			Acquisitions.				Appropriations.		Remarks.
					Nature of Acquisition.	Cost.			Nature of.	Date.	
		Ac.	r.	p.		£	s.	d.			
Lane Cove ...	Reserve Burns Bay ...	1	0	0	... ...	...			Dedicated...	13 Mar., 1877	
" ...	" Fig Tree Bridge	1	1	22½	... ...	...			"	10 Sep., 1886	
" ...	Lane Cove Park at	4	0	39	... ...	...			"	11 Jan., 1889	
" ...	Longueville	1	0	22	... ...	...			"	"	
" ...	Central or Federal Park	3	0	0	... ...	...			"	"	
" ...	at Longueville										
" ..	Reserve at Greenwich ...	0	2	0½	... ...	...			"	27 June, 1893	
" ...	Longueville Park, N'wood	4	2	21	Resumed 1 Dec., 1900 ...	1,410	10	2	Proclaimed	27 Feb., 1901	
		1	0	38¼	... ...	...			Dedicated...	22 Sep., 1888	
Leichhardt ...	Leichhardt Park	31	3	0	(See remarks) ...	5,694	11	0	Proclaimed	20 Sep., 1887	24a 2r 18p resum.
" ...	Reserve 30970 Long Cove	4	1	39	... ...	...			Notified ...	19 May, 1900	rest recl. land
Manly	Manly Park	12	2	22	(See remarks) ...	7,306	10	0	Proclaimed	30 Sep., 1887	2a 3r 36p resumed
"	Esplanade Park	14	0	0	... ...	...			"	19 Feb., 1892	7 June, 1887,
"	East Esplanade Park ...	2	2	0	Resumed 7 June, 1887...	...			"	20 Sep , 1887	9a 2r 29p Cr.
"	Central Park	1	3	22	" " ...	...			"	"	Purchase
"	Kangaroo Park	3	0	0	" " ...	...			"	"	
"	Tower Hill Park... ...	1	3	20	" " ...	...			"	"	
"	Gilbert Park	0	0	31	" " ..	...			"	"	
"	The Steyne	8	3	6	... ...	...			Dedicated...	14 Nov. 1879	Used as part of
"	South Steyne	1	2	0	" " ...	...			Proclaimed	20 Sep., 1887	"
"	Reserve at Balgowlah ...	5	2	23	... ...	...			Dedicated...	30 May, 1890	"
"	" "	10	3	0	... ...	...			"	"	"
"	" " port. 84	29	0	0	... ...	...			"	5 May, 1876	
"	" adj. The Steyne ...	4	0	15	Private dedication, vested in Mun. Council	...			...	...	
"	" " Esplanade Pk,	0	2	20		...			...	...	
"	" " "	0	3	31	" " ...	...			...	...	
"	" " "	0	0	10	" " ...	...			...	...	
"	" 31732 Cabbage Tree Bay	10	3	8	By Exchange	...			Notified ..	10 Nov., 1900	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area.	Acquisitions.		Appropriations.		Remarks.
			Nature of Acquisition.	Cost.	Nature of.	Date.	
		Ac. r. p.		£ s. d.			
Marrickville ...	Marrickville Park ...	10 0 0	Crown Purchase ..	10,516 13 4	Proclaimed	13 Oct., 1893	
" ...	Reserve on Cook's River at Tempe	4 0 19	... ...	...	Dedicated .	27 July, 1895	
Marsfield ...	Reserve portions 652, 653, 658 and 659	23 1 7	... ...	...	Dedicated .	17 May, 1895	
" ...	" 12560	2 0 16	... ...	...	Proclaimed	4 Oct., 1890	Field of Mars Act
" ...	" part of port. 512	abt. 19 0 0			Reserved in	Subdivision of	
" ...	" Brown's Water Hole	18 2 32	... ...	...	Fiele of Mars	Common, but	
" ...	" Blaxland's "	22 3 35			not formally	appropriated	
Mosman ...	Curraghbeena Park ...	3 2 7	... ...	...	Proclaimed	2 Sept., 1887	Reserves made on
" ...	The Spit Reserve ...	18 1 2	... ...	...	Not formally	appropriated	Military Land
" ...	Balmoral Park	8 2 10	... ...	...	Proclaimed	9 Mar., 1886	by consent of
" ...	Reserve Chinaman's Bch	2 0 28	... ...	...	Dedicated...	19 Oct., 1894	authorities
" ...	" 27961 George's Head	16 0 6	... ...	...	Notified ...	23 July, 1898	who retain
" ...	" 27962 Bradley's Head Road	14 0 14	... ...	...	"	"	right of entry at any time
" ..	" 23919 Mosman Bay	0 0 23	... ...	...	"	8 Feb., 1902	£300 contributed
" ...	Mosman Park	6 1 10	Crown Purchase ...	3,300 0 0	Dedicated...	1 Sep., 1900	by residents
Newtown ...	Nil						
North Sydney...	Camaray Park	48 3 21	... ..	...	Proclaimed	7 Dec., 1886	
" ...	St. Leonards Park ...	40 2 11	... ...	...	"	4 Sep., 1891	
" ...	Lavender Bay (Baths &c.)	1 0 32	... ...	...	Dedicated...	19 May, 1868	
" ...	Reserve Town N. Sydney	0 1 32	... ...	...	"	2 May, 1893	
" ...	Warringa Park, Neutral Bay	4 1 16 1 1 34	... ...	...	"	8 Oct., 1898	
" ...	Kirribilli Park, Careening Cove	2 1 37	... ...	...	"	29 Oct., 1898	
Paddington ...	Hampden Park	14 0 22	Crown Purchase ...	...	Proclaimed	14 July, 1897	
Petersham ...	Petersham Park... ...	8 3 3	By closing of Street ...	10,672 7 11	"	30 Sep., 1887	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area. Ac. r. p.	Acquisitions. Nature of Acquisition.	Acquisitions. Cost. £ s. d.	Appropriations. Nature of.	Appropriations. Date.	Remarks.
Petersham ...	Petersham Park add. area	0 3 0	... ...	...	Proclaimed	17 May, 1899	
Randwick ...	Randwick Park	25 0 0	... ...	...	Dedicated...	29 April, 1884	
" ...	Bangor Park	3 3 36	... ...	...	Proclaimed	29 Dec., 1887	
" ...	Milton Park	2 1 10	... ...	...	"	"	
" ...	Neptune Park	1 0 25	... ...	...	"	"	
" ...	Smithfield Park	3 0 0	... ...	...	"	"	
" ...	Hampstead Park... ...	1 2 30	... ...	...	"	"	
" ...	Writtle Park	1 0 19	... ...	...	"	"	
" ...	Blenheim Park	3 0 15	... ...	...	"	"	
" ...	Centennial Park (part)...	abt. 585 0 0	... ...	...	Proclaimed	16 Feb., 1900	See also Sydney and Waverley
" ...	Reserve at Allison-street	4 2 1	... ...	...	Dedicated...	4 Feb., 1876	
" ...	" Little Coogee...	2 2 2	... ...	...	"	23 April, 1895	
" ...	" " ...	5 2 0	... ...	...	"	17 May, 1895	
" ...	High Cross Res. Avoca-st.	0 2 38¼	... ...	...	"	23 May, 1879	
" ...	Reserve Swamp-st. Coogee	2 1 20	... ...	...	"	"	
" ...	" "	2 2 14	... ...	...	"	"	
" ...	" Neptune and Dudley-sts.	2 1 4	... ...	...	"	11 June, 1886	
" ...	" "	1 1 37	... ...	...	"	"	
" ...	" Shark-st., Coogee	10 2 0	... ...	...	"	2 May, 1893	
" ...	" Coogee Beach ...	8 3 16	... ...	...	"	1 June, 1866	
" ...	" " ...	2 1 28	... ...	...	"	"	
" ...	" " ...	4 0 0	... ...	...	"	"	
" ...	" " ...	4 3 0	... ...	...	"	"	
" ..	" " ...	3 0 16	... ...	...	"	"	
" ...	" 23068 Botany ...	727 0 3	... ...	...	Notified ...	30 Nov, 1895	
" ...	" 26569 La Perouse	4 2 5	... ...	...	"	2 Oct., 1897	
" ...	" Cricket Gd. Coogee	4 0 0	... ...	...	Dedicated...	1 June, 1866	
" ..	" Orange-street and Frenchman's Rd.	0 1 26½	... ...	...	"	4 July, 1896	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area.			Acquisitions				Appropriations.		Remarks.
					Nature of Acquisition.	Cost.			Nature of.	Date.	
		Ac.	r.	p.		£	s.	d.			
Randwick ...	Reserve Randwick Race C.	202	0	0	... ...	...			Crown Grant	15 June, 1863	
„ ...	„ 32795 at Long Bay	62	0	0	... ...	...			Notified ...	22 May, 1901	
„ ...	„ 32796 „	320	0	0	... ...	..			„	„	
Redfern ...	Redfern Park	11	3	24½	Crown Purchase ...	34,834	0	0	Proclaimed	10 Nov., 1885	
Rockdale ...	Arncliffe Park	9	2	13¼	„ „ ..	4,000	0	0	„	22 Mar. 1889	
„ ...	Scarborough Park ...	97	0	0	... ...	...			Dedicated ..	23 May, 1879	
„ ...	Cook's Park, Botany Bay	64	0	0	Resumed 20 Oct., 1885 ..	1,270	12	1	Proclaimed	30 Mar., 1886	
„ ...	Rockdale Park	8	1	27	Crown Purchase ...	700	0	0	„	10 Feb., 1900	
Rookwood ...	Reserve	15	1	30	... ...	...			Dedicated...	25 Oct., 1892	
Ryde	Reserve 4685	85	2	28	... ...	...			Proclaimed	3 Dec., 1887	Field of Mars Act
„	„ at Buffalo Creek...	19	1	20	... ...	...			Reserved in	Subdivision of	
„	„ Pitt Water Road	5	1	13	... ...	...			Field of Mars	Common but	
„	„ Lane Cove, Portions 368, 369	10	2	6	... ...	...			not formally	appropriated	
„	„ „ „ 401	7	1	23	... ...	...			„	„	
„	„ „ part port. 512	15	0	0	... ...	...			„	„	For balance see
„	„ at Ryde	0	0	14	... ...	...			Dedicated...	25 July, 1884	Marsfield
Strathfield ...	Nil										
St. Peters ...	St. Peters Park	10	0	0	... ...	...			„	15 Sep., 1891	
„ ...	„ addition	1	3	21¼	Resumed 2 Dec. 1892 ...	...			...	Not yet	formally set apart
Sydney	Moore Park	378	0	0	... ...	...			Dedicated ..	5 Oct., 1866	This area includes
„	Phillip Park	3	1	15	... ...	...			„	3 May, 1878	the whole of
„	Cook Park	3	2	3	... ...	...			„	„	Moore Park as
„	Prince Alfred Park ...	18	3	0	... ...	...			„	22 Dec., 1865	now set apart
„	Belmore Park	10	0	0	... ...	...			„	19 May, 1868	for recreation,
„	Hyde Park	40	0	0	... ...	...			„	3 May, 1878	the Associa-
„	Observatory Park ..	6	1	0	... ...	...			Proclaimed	6 Nov., 1887	tion Cricket
„	Wynyard Park	2	0	0	... ...	...			„	7 Oct., 1887	Ground, Royal
„	The Domain	90	0	0	... ...	...			Colonial Sec.	6 Jan , 1855	Agricultural
„	Botanic Gardens and Garden Palace Gds.	60	0	0	... ...	...			Letter 55/15 „	„	Ground, and the Zoological
„	Reserve at Church Hill...	0	2	37¾	... ...	...			Dedicated...	21 Dec., 1866	Gardens

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.	Area.				Acquisitions.				Appropriations.		Remarks.
			Ac.	r.	p.	Nature of Acquisition.	Cost. £	s.	d.	Nature of.	Date.	
Sydney	Reserve Argyle Place ..		0	0	33	... ...	...			Dedicated...	6 Dec., 1867	
„	„ Macquarie Place		0	1	21	... ...	...			„	5 Oct., 1887	
„	Rushcutter's Bay Park (pt.)	abt.	13	0	0	Part reclaimed and part resumed under Rushcutter Bay Act of 1878.	...			Proclaimed	11 Dec., 1885	For balance see Woollahra
„	Bare Park, Elizabeth Bay		...			Reclaimed by Municipal Council, and adjacent land reserved in private subdivision.						
„	Green Park, Burton-st....		1	0	0	... ...	...			Dedicated...	31 Aug., 1875	
			0	1	14	... ...	...			„	15 Aug., 1871	
„	Wentworth Park (part)	abt.	6	2	0	... ...	...			Proclaimed	10 Nov., 1885	See unincorportd.
„	Centennial Park „	„	30	0	0	... ...	...			Act 51 Vic. 9	16 Feb., 1900	See Waverley and Randwick
Vaucluse ...	Gap Park		9	1	4	... ...	...			Proclaimed	28 June, 1887	
„ ...	Camp Cove		0	2	20	Resumed 18 Jan., 1887...	...			„	29 Mar., 1887	
„ ...	Reserve 33853		0	1	18¾	... ...	...			Notified ...	8 Feb., 1902	
Waterloo ...	Waterloo Park		7	1	1	Resumed 1 Oct., 1886 ..	12,572	7	11	Proclaimed	25 Jan., 1887	
Waverley ...	Waverley Park		27	2	10	Crown Purchase ...	7,500	0	0	...	Not formally appropriated	
„ ...	Dickson Park		2	2	37¼	... ...	...			Proclaimed	30 Sep., 1887	
„ ...	Varna		3	2	22½	... ...	...			„	„	
„ ...	Simpson		0	1	33¾	... ...	...			„	„	
„ ...	Macpherson Park ...		0	2	30¼	... ...	...			„	7 Oct., 1887	
„ ...	Bronte Park		14	0	0	Resumed 22 Oct., 1886...	6,386	12	4	„	25 Jan., 1887	
„ ...	Bondi Park		28	0	2¾	Crown Pur. 0 2 26¾; Res. 9/6/82 25 2 16; Crown Land 1 3 0	11,153	14	6	„	29 Oct., 1889	
„ ...	Centennial Park (part)...		130	0	0	... ...	...			„ A. 51 V. 9	16 Feb., 1900	See also Sydney and Randwick
Willoughby ...	Chatswood Park		4	3	2½	Crown Purchase ...	1,377	10	0	Proclaimed	7 June, 1899	
„ ...	Beauchamp Park ...		11	0	32	„ „ ...	1,680	0	0	„	25 Oct., 1899	
„ ...	Gore Hill Park, R. 29836		17	2	10	... ...	...			Notified ...	28 Oct., 1899	
„ ...	Naremburn Park, R. 30156		6	3	32	... ...	...			„	4 Nov., 1899	
„ ...	Reserve Mowbray Point, Middle Harbour		5	0	23	... ...	...			Dedicated...	20 Aug., 1886	
„ ...	„ 43 Sugar Loaf Bay Middle Harbour		37	0	0	... ...	...			Notified ...	1 Oct., 1879	

PUBLIC PARKS AND RECREATION RESERVES WITHIN THE CITY OF SYDNEY AND ENVIRONS.

Municipality.	Park or Recreation Reserve.		Area. Ac.	r.	p.	Acquisitions. Nature of Acquisition.	Cost. £	s.	d	Appropriations. Nature of.	Date.	Remarks.
Willoughby ...	Reserve Portion 259 Parish Willoughby		5	1	25	... ...	...			Dedicated...	16 Dec., 1884	
„ ...	„ „ „		0	2	11	... ...	...			„	„	
„ ...	„ 21525 Elizabeth Rd.		0	3	23	... ...	...			Notified ...	15 Sep., 1894	
„ ...	Artarmon Park, R 31309		7	0	0	... ...	...			„ ...	11 Aug., 1900	
Woollahra ...	The Steyne, Double Bay		3	0	35	... ...	...			Dedicated .	6 Dec., 1867	
			0	1	4	Resumed 2 Dec., 1892 ...	3,139	10	6	„	19 Oct., 1894	
„ ...	Rose Bay Park		6	2	17	Resumed 18 Nov. 1884	15,425	2	6	Proclaimed	14 Feb., 1888	
			0	1	23	Deed of Gift to Crown						
„ ...	Rushcutter's Bay Park (part)	abt.	14	1	13	Partly Resumed and partly reclaimed under Rushcutter's Bay Act of 1878				„	11 Dec., 1885	For balance see Sydney
„ ...	Bellevue Park		1	0	25	Resumed 11 May, 1888 .	...			„	2 Nov., 1888	
„ ...	Harbour View Park ...	abt.	2	0	0	Private Dedication ...	...			...	Deed of Gift	to Municipal C.
Unincorporated	Wentworth Park (part)...	„	23	1	32	... ...	...			„	10 Nov., 1885	For balance see Sydney
„ ...	Federal Park, Res. 30122 Rozelle Bay		16	1	20	... ...	...			Notified ...	11 Nov., 1899	
„ ...	Kurnell Park, Cape Solander		35	2	13	Resumed 22 March, 1899						
„ ...	„ „ „		2	0	8	„ 26 April, 1899	1,780	12	4	Proclaimed	12 April, 1902	
„ ...	„ „ „		25	2	19½	„ 2 May, 1899 ..						
„ ...	„ „ „		184	2	39½	Crown Land						
„ ...	Clark Island Pt. Jackson		1	2	35	... ...	...			Dedicated .	16 April, 1879	
„ ...	Schnapper „ „ ...		0	1	24	... ...	...			„	„	
„ ...	Rodd „ „ ...		1	0	23	... ...	...			„	„	
„ ...	Shark „ „ ...		2	3	27	... ...	...			„	„	

NOTE—The term "*Proclaimed*" under the heading of "Appropriations" unless otherwise specified refers to action taken under the "Public Parks Act of 1884." The terms "*Dedicated and Notified*" refer to action taken under the "Crown Lands Alienation Act of 1861" and "Crown Lands Act of 1884."

It will be observed that the Sydney district has a creditable list of parks, but they are somewhat unequally distributed. Thus Randwick and Manly possess far more than the average, while an important Municipality like Strathfield does not possess even one. Burwood, Enfield, Canterbury, Marrickville, and perhaps others should secure additional public reserves before the price of land is further enhanced. Could not some areas of land be dedicated by public spirited persons to commemorate the Coronation? A park is the most enduring of all monuments and a perpetual source of good. I do not suggest that further applications should be made to Government for park-lands at the present time.

d. *Park-lands should be inalienable.*—I think I may state as an axiom that portions of most public reserves in the district are liable to be built upon or to be used for purposes other than park purposes. It is simply a question of expediency that some of our parks or reserves are not diminished in area. My opinion is that in this democratic country it should be at least as difficult to alienate public recreation reserves (or any other portion of them) as it is in Europe. In most European countries the attempted alienation of a public reserve would be followed by disturbances. In those countries so many areas have been secretly enclosed by adjoining landowners that organizations exist, supplied with voluntary contributions and officered by resolute men, to enquire into and if necessary, take suitable action in regard to any reported filching of the public estate, or curtailment of public liberties.

Parks should be inviolable, because diminution of area means diminution of opportunity of recreation. But there is another very important consideration in regard to taking from the area of a park. If a man sets himself to improve a certain area from a landscape point of view, his plans may

be destroyed, and the money expended on the park largely thrown away if an area be excised or the park cut into two. New conditions thus arise and he has to prepare new plans with the view of meeting the changed conditions. And while he is progressing in this matter there is no guarantee that a fresh interference with the park may not again destroy what has been done. Again, trees which are planted for shade and sylvan effect, or simply to hide unsightly views or objects are of slow growth. Suppose a farmer were to cultivate a twenty-acre paddock; if two acres of this be resumed, in most cases the result is that his operations continue on the smaller area just as they did on the larger, the only difference being that his work and crop are alike reduced ten per cent. But the matter is usually totally different in treating a landscape. The resumed area may become an eyesore to the main portion, distinctly injuring it from an æsthetic point of view. And in a park æsthetic considerations come only second to hygienic ones.

Mr. John Barlow, President of the Institute of Architects of New South Wales, has in his official position made numerous protests against any diminution of the area of public parks by the introduction of anything which will damage them from an æsthetic point of view. His remarks have been warmly applauded by his confrères, all trained lovers of art, and our Government Architect, Mr. W. L. Vernon, has always lent the weight of his influence to improve our public parks along right lines.

H. Police and Traffic Regulation.

a. *Police.*—In my opinion the rangers or bailiffs of all public parks should be members of the State police-force, and under the control of the Inspector-General of Police. With such an arranagement the rangers would be under suitable discipline, and they would be all trained men, for a policeman is a product of long and careful training. They

would not be permanent rangers, but would be detached for this special duty for a period to be fixed by the Inspector-General, and they would thus be available for transfer, on promotion, or otherwise, like any other policeman. A great advantage of the arrangement would be that the rangers would be in close touch with their superior officers, and thus the difficulty of bad characters making habitual use of parks for criminal and vicious purposes would be much increased. Last, but certainly not least, I am a great believer in the value of a police-uniform for the maintenance of order, particularly amongst young people, in a public park. The mere presence of the uniform has a wonderful effect. When detective work is required, the services of plain-clothes constables can be called into requisition.

b. *Traffic regulation.*—Wheeled traffic in parks is permitted only so far as it enhances the public enjoyment of the park. By means of a vehicle a citizen (whether invalid or not) can take the air and visit distant parts of a park without fatigue. The driver of a vehicle should be especially considerate to a pedestrian in a public park. Miscellaneous traffic is undesirable in a park, as it interferes with its restfulness and beauty.

There are several reasons why carriages are not permissible in public parks at night.

1. No matter how well a park is lighted, vehicular traffic is more dangerous to the pedestrian at night than by day, and a feeling of insecurity takes away the restful feeling which it is one of the objects of a park to secure.

2. The regulation of vehicular traffic at night is costly.

3. Vehicles may deposit rubbish in a park under cover of the darkness.

4. Vehicles provide facilities for certain forms of vice, particularly amongst the well to do.

The word "carriage" in common use in by-laws of parks has been held, by a Judge of the High Court in England, to be large enough to include a machine, such as a bicycle, which carries the person who gets upon it, and such person may be said to "drive" it. The opinion of the Crown Solicitor of New South Wales is that in the Domains Regulation "the word 'vehicle' used in the Regulation referred to which provides that no person shall ride or drive any kind of vehicle within the Domains except on the roads laid out therein, includes 'cycles'." This is a matter of considerable importance in the proper control of parks. The drivers of motor cars are amenable to the law as far as furious driving is concerned in precisely the same way that drivers of other vehicles are.

III. Roads and Paths, Fences, Seats.

a. *Roads and Paths.*—It is an axiom in park management that people will make their own paths if permitted. This is quite true, but we must be careful not to give false interpretation to the public wish. Given a uniform open plain the public may well be left to make their own tracks which may form the route of the future road. But people always avoid obstacles,—such as water, mud, hard and especially broken stone, smooth pebbles, tree-stumps, and so on. So that the pioneer road, even in a park, is a sinuous track. All that these go as you please roads are useful for are as indications of the general trend and volume of the traffic.

I prefer gravel paths, well rolled and with good blinding material. They are cool and pleasant to the feet and contrast well with the grass. Asphalt paths are suitable for steep grades and for places where there is much traffic, as a clean, uniform road is thus secured.

Visitors to Europe are struck with the absence of side drainage in the parks and gardens there. This shows that

in that continent, although the rainfall is considerable, it is gradual, and that the tropical downpours we have in Sydney seldom occur. Our Sydney paths have to be carefully graded and usually drained on both sides with gutters, (I prefer semi-circular glazed tiles). Without side drains those dainty well raked gravel paths of Europe would be frequently washed away. With all our precautions no human foresight can prevent much damage from this cause in Sydney.

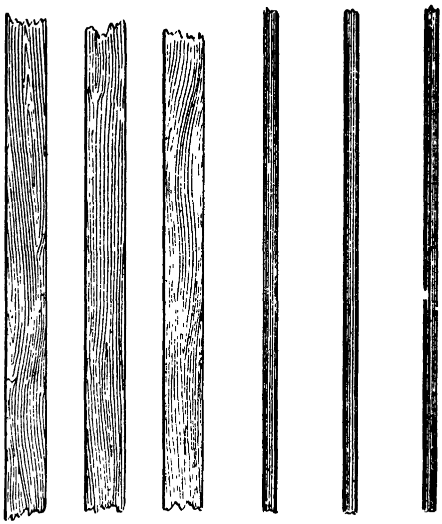
A good macadamised road is one of the best for a park, but during our long spells of dry weather it requires watering and a good deal of attention in other ways, to prevent the stones working loose.

An asphalt (or to speak more strictly tar-paved) road is a rarity in Sydney, though roads of true asphalt are common enough in London and other large cities. Such roads have the very great merits in a park of cleanliness, smoothness, and consequent quietness, but have the disadvantages of dismal colour, and of reflecting too much heat. The tar-paved roads of which I speak, possess some of the merits both of macadam and true asphalt, but are inferior in durability to the latter. The finest asphalt (tar-paved) road in Sydney is in the Centennial Park ; it is 33 feet wide, and is at present 100 chains long, fresh portions being converted from macadam into tar-paving each year.

We have a grass Ride in the Centennial Park 39 feet wide and 192 chains (*i.e.*, 2¼ miles, 12 chains), long. I have not figures in regard to similar Rides in public parks in Europe, but they are apparently not numerous. I observed one in the Thiergarten of Berlin, about 20 feet wide, but it was much cut up when I saw it.

b. *Fences.*—A park should be securely fenced, but the fence should be artistic. In city parks I prefer the stone coping and iron-railing. Galvanised iron should not be

permitted as a park boundary; where a close fence is desired, it should be of overlapping weather-boards. Picket fences are a compromise between the close fence and the iron-railing. The diagram herewith shows at once how a picket fence interferes with people looking into and out of a park.



Picket Fence *Iron Railing*

I am averse to a close fence, as it is apt to encourage untidiness. Fences accumulate rubbish and make plants tender and unsymmetrical. The railing enables people to see into the dark corners, and rubbish and badly grown plants, are at once noticed. Close fences enable bad characters to conceal themselves. An open railing is a good policeman. I am afraid that we are not sufficiently advanced yet for the abolition of the fence or railing, leaving only a dwarf stone coping as in parts of America and England.

A railing is looked upon by many people as contributing an element of security, without which there can be no enjoyment in a park. It keeps out stray or bolting animals from the streets; it also, renders protection of plants and other park property more easy. America is often quoted as the country where people respect their parks, but citizens even in that country have still much to learn in regard to the care of parks. The annual report of the Chief of Engineers of the U.S. Army on the Washington parks is pitiful reading, showing that human nature is much the same in the United States as anywhere else.

Further, green swards are kept in order in New York and other parks at a cost to the freedom of action of the public that would never be tolerated in democratic New South Wales. I know law-abiding citizens who have been bullied by American police for infringement of petty yet Draconian Park by-laws, which can only have been framed on the principle that "the people exist for the park." In my opinion "the park exists for the people." The parks of Europe bristle with directive and minatory notices which are quite unsuitable to Australian conditions. I think all park-superintendents would gladly be without the worry of the up-keep of fences and the management of entrances, but democratic as I am in my ideas, I repeat that the time is not ripe yet.

Entrances should be sufficient in number. How irritating it is to the citizen to have to walk a considerable distance around his park to get into it. It is like being shut out of paradise. The entrances should be as numerous as the topography of the land or its landscape design will permit. Entrances are the beginnings of paths and roads, so they cannot be made haphazard. They should be made with careful consideration of the flow of traffic in the streets outside the park boundary.

Trees in parks should be protected by guards. Iron tree guards made of half-inch round iron are best, and can be made graceful. Where there are stock, it is desirable to further protect the tree by means of a low single arris rail at some distance from the iron tree-guard.

c. *Seats.*—The question of seats is an important matter in a public park. In those that are closed at night, a light moveable seat, made of wooden laths and thin wrought iron framework is comfortable and neat in appearance. In parks open all night, the benches or seats should be heavier in character and fixed in the ground. I have adopted a

pattern in which the seat itself is curved so as to afford comfort to the sitter. In setting a bench the seat itself should not be horizontal, but should be raised a little in front, thus throwing the occupant a little back, as that posture conduces to rest.

The question of paint for seats and rails in parks is sometimes debated. Some people prefer green, as being theoretically the most natural colour, harmonising with everything around. Unfortunately, during our hot summers, trees and grass etc., are often not green, but even with all vegetation "in verdure clad," it may not follow that inanimate objects in the vicinity, such as fences, railings, and seats should be similarly coloured; also, owing to its lack of durability, green paint soon becomes of a sombre, unattractive hue. I prefer a quiet stone-colour as the most appropriate for our parks. It has the merit of durability, and has a bright clean appearance. Clean paint is necessary in a public park for the sake of appearance and also on sanitary grounds. Accordingly all seats and rails should be painted once a year. This arrangement is also most economical in the long run, because of the improved durability of the wood or iron.

IV. Plantations, Grass, Depasturing of Stock.

a. *Plantations.*—The planting of a park can only be touched upon, at this place, in a general way. In its laying out, the indigenous trees should be conserved if possible; I do not say at any price. Some trees should be cultivated for the purpose, mainly, of giving shelter to the public. The problem of producing beautiful landscape effects is not one suitable for discussion here, except in very general terms, for one cannot go into essential details except with

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[1] Since the above was written an article has appeared on "Green Paint in the garden landscape."—(*The Garden*, 22nd March, 1902, p. 185). The article mainly discusses the tints of green for plant boxes, and the subject deserves more ventilation than it usually obtains.

a particular block of land in view. Trees in a public park must have their lower branches removed or children will break them down, and improper characters will use them as places of concealment. In a private park we see noble specimens of trees, some of them with branches close to the ground. When for public-park purposes we prune them we not only seriously detract from their beauty, but in the case of some trees, particularly Conifers, we inflict great injury upon them from a physiological point of view. Trees often require a little judicious pruning, either because of accidents to branches, or to prevent branches becoming unduly heavy and tearing themselves away during winds or by their sheer weight. Then we require special precautions in regard to the danger from trees in a public park, particularly in those used by large numbers of people. Just as a man periodically taps the wheel of a railway train to detect a flaw, if any, so it is the duty of a park officer to frequently inspect his trees to see if any of them present symptoms which will cause them to be dangerous to the public. Are they getting top-heavy? Are the branches or the trunks becoming unsound? The pruner and the axeman must be ever on the alert, especially as, with all our care, trees sometimes fall without warning. In such cases examination of the roots or inner portion of the trunk reveals insidious disease caused either by micro-fungi or by insect pests.

The chief time of anxiety from falling trees is during a period of heavy rain accompanied by strong winds. The ground becomes sodden and holds the roots with difficulty, while the more umbrageous the tree the less able is it to withstand the strongest blast of a gale. And it is sometimes one blast that does the mischief. The climbing of trees by boys is a very serious cause of their injury, and even destruction. If a boy intends to climb a tree one cannot, in practice, prevent him, but he can be hindered by

tree guards, and also by loosely twisting barbed wire around the first fork. Insect pests are a constant source of anxiety in parks, and frequently require a spraying plant to cope with them.

While many trees in our genial climate grow more rapidly than they do in Europe, one must not lose sight of the fact that they attain maturity quicker and then show signs of failure. In applying remedies to unhealthy trees, one must carefully distinguish between those which are suffering from the effects of accident or from a passing ailment, and those in which the real cause is senile decay.

The question of the establishment of wind-breaks is a matter of importance to all custodians of parks which are not blessed with a sheltered situation. This is one of the most difficult problems those in charge of parks have to face. The problem is to establish the first line of defence which, in its turn, may protect the second, and so on. Each man must work out the problem for himself, and he of course considers the contour of the land and the direction and force of the prevailing winds. Those interested in the matter may be inclined to study the methods by which wind-breaks are being established at the Centennial Park.

I do not propose to enter into details in regard to methods of tree-planting, for no intelligent local authority will entrust the planting of trees to a person other than a gardener, any more than he will entrust the repairs of his watch to anyone who is not skilled in that particular kind of work. Let me, however, point out that a large part of Sydney, including some Sydney parks, consists mainly of sandstone or of pure sand. To plant trees in the former requires extensive blasting and much good soil; to plant trees in pure sand without the admixture of good loam is not only a waste of time, but is a misappropriation of public

funds. Our natural difficulties are quite numerous enough without making pretences to perform impossibilities.

b. *Grass.*—Grass gives charm to a park, which can be obtained by no other means. Refreshing to the eye, it it is Nature's own carpet on which the weary citizen may rest. The grass in most of our Sydney parks is the Indian Doub or the "Bermuda Grass" of the United States, (*Cynodon dactylon*, Linn.) which is universally known in Sydney as Couch Grass. It is a native of Australia as well as of other parts of the world; at the same time it is an immigrant in certain districts in which it is now well established. It forms a fine, smooth, durable lawn.

The other grass is known by all Sydney people as Buffalo Grass (*Stenotaphrum americanum*, Schrank.). It is a coarse, springy grass much approved by some people, although too coarse for tennis or croquet lawns or for cricket. It is an American grass, but not the Buffalo grass of America,[1] which is *Buchoë dactyloides*, Engelm. The grass called Buffalo grass in Sydney is so called because its first discovery in Australia was made on the shore of Buffalo Creek, a small tributary of Port Jackson.

c. *Depasturing of Stock.*—In most Sydney Parks stock are allowed to be depastured on agistment. In the State parks they are used as a substitute for scythes and lawn-mowers. Financial considerations partly weigh with us as regards the Domain; for example, by stock a revenue of £60 to £100 per annum is secured (the lessee of the grazing being responsible for the stock), while the manure fertilizes the ground. To mow the Domain grass as well as the stock do it would be impossible, as the ground is too irregular in contour; to keep it moderately well cut would cost at least £400 a year. On the other hand the

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[1] In the United States it is known as Mission Grass, or St Augustine's Grass.

presence of cattle is sometimes objectionable through deposits of manure on the paths, and frightened horses sometimes chip the stonework of kerbs and steps. Sheep are better animals for keeping the grass of parks in order, but the Sydney climate does not suit them, and it is usually inconvenient to make suitable arrangements with butchers for the loan of them. Then, as they are so readily interfered with by children and others, they cannot be employed in parks unless there is a shepherd, or where there are special circumstances which render the supervision of them convenient.

While the use of stock as lawn-mowers has the drawbacks stated, I am of opinion that, in some parks, the advantages of their employment far outweigh their disadvantages; certainly complaints on the part of the public in regard to them are few and far between. The plantations (if any) in a park require to be fenced if stock are to be admitted, while the condition is always insisted upon that none but quiet animals are admitted. I think a few horses quietly grazing, or cows peacefully chewing the cud in a park, supply an element of beauty and of rural peacefulness that gives an added charm to a people's park, particularly in crowded cities where children are usually debarred from the pleasure of seeing animals under rural conditions.

V. BUILDINGS ETC. IN AND ABBUTTING ON PARKS.

a. *Buildings.*—It is a truism that no structures should be erected in a public park which are not necessary to carry out the objects of the park. Thus, administrative offices, places for the storage of material, such as road-metal, tar, timber, tree-guards, soil, etc.; also workshops (including plant-frames and other appliances for the propagation of plants), are necessary; so are buildings for public refreshment, lavatories etc., band-stands, shelter-pavilions,

fountains and so on. All these buildings should be designed so as to be neat and ornamental in appearance and in harmony with their surroundings.

I have already laid stress on the necessity for the inalienability of lands reserved for park purposes. At present parks are liable to be built upon, to be encroached upon by railways or tramways, or to be otherwise contracted in area. The temptation to the erection of a building in a public park, be it museum, library, or picture gallery is an insidious danger. The display of beautiful and useful objects *inside* a building may be secured at an appalling price in regard to nature's beautiful and permanent vistas *outside*. The danger of the erection of buildings in public parks is enhanced by the feeling that sometimes obtains that the money value of a piece of park land need not be taken into consideration. Thus if it be desired to put a building, costing £10,000, on a piece of park land whose market value is £5,000; the cost of that building is £15,000, and it is not fair to represent that its cost is £10,000. Furthermore, public buildings once erected in a public park are not always limited by fixed boundaries as is the case where the land has to be paid for. Cases have been known in which the land taken from a public park has been found inadequate, and additional ground has been obtained by the simple process of putting back the fence.

The question of the erection of buildings in public parks is one of paramount importance to the public, and to the landscape gardener. A building in a park is an item in the landscape, and it must be subordinated to the park as a whole.

In Europe the relation of buildings to private and national parks and gardens is well understood, and incongruities are few. The United States has passed through the trial stage which new countries such as ours have to pass

through before the sacredness of the public parks is respected. Following are some pertinent extracts from "The Garden and Forest" of New York, Vol. x. (1897), which are worthy of perusual.

"What we wish now to point out is that it seems probable that more and more schemes to further definitely intellectual or æsthetic ends will be prosecuted without due regard to the integrity and beauty of our parks as works of landscape art, and that the patrons of science and literature and of art of other kinds are likely to try to injure our great artistic creations like Central and Prospect Parks. And this is, of course, a very insidious danger, as the schemes may be worthy in themselves, and the people who urge them are those whom the public has been told it should trust most implicitly in intellectual and artistic matters. . . .

"These few instances illustrate one phase of apprehension,—the danger that buildings for public purposes will more and more absorb the narrow and precious spaces set apart for the people's refreshment and enjoyment. Each such instance is deplorable in itself, and as a precedent for future enterprises of similar kind. Nor is New York the only city which needs to be warned along these lines. The beautiful park which Mr. Olmsted laid out in Buffalo is threatened with the erection of buildings which would be public benefits if placed elsewhere, but public misfortunes as features in a naturalistic park. Even the small and incomparably precious State Reservation at Niagara Falls has had to be defended against a misfortune of a like sort; and there is no town in the United States whose parks are safe in this respect. It is high time that the public should awaken to the fact that no buildings whatsoever, except those absolutely required for park purposes proper, should be allowed within a park, and that the projectors of all others should buy their own sites or, if these must be purchased with public money, that they should be placed outside of park limits.

"This is not merely because every foot of open public land is precious as such, and should be held sacred to serve the health, the refreshment, and the outdoor pleasures of the people. It is also because, almost without exception, our pleasure-grounds are works of lanscape-art in the exact sense—naturalistic parks—and are necessarily injured in their artistic character by the intrusion of buildings even of the most beautiful kinds. This is the point which many artists do not understand, and, therefore as they are naturally regarded as the highest authorities in artistic matters, the damage which may be done to our parks by those whe have not a true comprehension of them is, perhaps, more to be dreaded than that from any other class of men."—(p. 439).

And again:—

"Yet the old idea that any person ignorant of art but possessing a "feeling for nature" is competent to decide any question with regard to a naturalistic pleasure-ground has not yet died out, and, on the other hand, those who are expert in artistic questions of some different kind do not yet understand that, nevertheless, they may be incompetent to deal with problems of naturalistic landscape-gardening.

"Vast formal pleasure-grounds such as were created around the palaces of the Old World, for the delectation of the frequenters of luxurious courts, are inappropriate to the needs of modern times; and this is especially true in our democratic country. Our parks, large and small, exist for the greatest good of the greatest number; and this good can best be secured by making them, within the bounds laid down by art, as much like Nature's landscape as possible. Only in this way can they fulfil the need of the populace for rest and refreshment, and bring Nature's peaceful, soothing, inspiring influences to bear upon the minds and bodies of those who live and toil amid the noise and stress of modern civic conditions; and only thus can they be genuine and characteristic works of American art, expressing the ideals and the temper of American civilization."—(p. 499.)

b. *Wharves.*—The "Sydney Harbour Trust Act, 1900," gives power to the Harbour Trust Commissioners to deal with frontages below high-water mark. The value of the numerous water-side parks as pleasure resorts, and of which the Botanic Gardens and Outer Domain are by far the most important, depends largely upon æsthetic considerations. If a portion of the water frontages are to be taken for utilitarian purposes by the Harbour Trust, the value of these reserves, which cannot be gauged in money, may be deteriorated to an extent that it may not be possible to compute.

No wharf, jetty, etc., ought, in my opinion, to be erected on any water-frontage to park lands by any authority without the consent of the Minister controlling the park in question. A Minister would doubtless be advised in the matter by his responsible officers as to the probable effect of the proposed structure on the park.

I venture to express the opinion that it was never the intention of the Legislature to place the National Recrea-

tion Reserves (Domain and Botanic Gardens), in the power of the Harbour Trust. I only mention these two reserves because they are the most important, and I imagine that a clause for the protection of these national reserves might fitly be inserted in an Amending Act of the Sydney Harbour Trust Act. These reserves are, I feel sure, in no danger from the present enlightened Harbour Trust Commissioners, but they might be succeeded by gentlemen who would be inclined to look upon public parks simply from a commercial point of view.

As an instance of the way in which the utilization of a park frontage for wharfage purposes may deteriorate a park, the south-eastern part of Woolloomooloo Bay affords an instructive example. Wharves are creeping along the Domain in that direction, and we already have nuisances from:—

1. *Smoke of steamships.* If a man on shore own a smoky chimney he is prosecuted, but the funnel of a steamship can belch forth smoke, darkening the air for a considerable distance and disfiguring the ground with smuts, but no prosecution follows. The north-easters (our prevailing winds during the summer months) blow this smoke into the Domain to the discomfort of citizens and to the injury of the vegetation.

2. *Stinking cargoes.* I have been made nearly sick when passing bags of horns and bones, hides and other abominations on the Woolloomooloo Wharf. What a regrettable arrangement it would be for a continuance of the wharves along the Domain frontage, especially since it would follow that these pestiferous odours would be wafted into the Domain and Gardens by the prevailing north-easter. It would be impossible to forbid our staple articles of export from being placed on a public wharf.

3. *The noise and bustle of shipping.* Noise and bustle are inseparable from shipping. The donkey-engines are noisy by day and night, and the varied and loud noises incident to shipping operations detract from the restfulness of a public park.

4. *Rats and shipping.* No matter what precautions are taken it is difficult to prevent rats leaving a ship for the land. In a public park food-refuse is always lying about and encourages the rat-scavengers. We have special reason to dread the presence of rats, and a public park should be an ideal health resort for the people.

I have dealt with the small wharves necessary for people to enjoy facilities for bathing, boating etc., and to obtain the maximum enjoyment from their parks, at p. 36.

VI. SPECIAL PUBLIC REQUIREMENTS.

a. *Neccssities*:—

1. *Lighting.* Why do we want light in a public park? For the same reasons that we want it in the public streets. We want it in order that we may see our way. We want it that we may walk as we choose, without being disturbed by the foot-pad or the larrikin. As matters stand, during the greater portion of the time (the evening hours) that promenade in a park is possible to the average man or woman, they are precluded from this pleasurable and health-giving exercise. The old stupid idea is that museums and picture-galleries are only to be opened during the period that the average citizen is at work. Parks certainly are available longer than that, but at night they should not hold out special inducements to criminal and vicious persons. On moral and hygienic grounds, therefore, let us have light in our parks.

It seems strange to have to insist upon light as an essential in a public park. Hyde Park, London, the prin-

cipal park of the principal city of the world was not safely lighted up till 1899, and then only the path from the Marble Arch to the Statue of Achilles. A leading London newspaper asked for still more light, stating that it would be the means "of relegating crime and vice to those obscure portions of the park remote from the frequented footways." In 1901, during the summer months, portions of the Outer Domain and Hyde Park, Sydney, were lighted by electricity, but the work was discontinued for financial reasons. Nevertheless the experiment was a useful one, and I now advocate the extension of gas-lighting. Incandescent burners give a brilliant light, and the average gas lamp is of a convenient height above the ground, giving the light where it is most needed. The gas is entirely under control, and noisy, dirty engines, hideous buildings and overhead wires which appear to be necessary where electricity is generated are entirely done away with, matters of supreme importance in a public park.

The lighting of Hyde Park, London, made one of the minor poets break into song less than three years ago:—

"For well I know what danger lurks
In all such mad progressive movements,
Electric lighting once obtained,
London will call for more improvements.
And I shall live—ah, cruel fate!—
To see Hyde Park, spite my endeavour,
Become a people's Paradise,
Bright, light, and beautiful for ever."—(London *Truth*, 1899).

2. *Sanitary matters.* The provision of water-closets and urinals in public parks is a matter of absolute necessity unless these conveniences are well provided outside in the vicinity of a small park. In large parks they are necessary, no matter what may be the arrangements outside the park-area. In the Botanic Gardens there is special accommodation for women and children; such has not been provided in our parks, so far as I am aware. All our most im-

portant parks ought to have such accommodation, and each châlet should be in charge of an attendant. I also think that each of the men's conveniences should be in charge of an attendant; this would prevent people stuffing boots and clothes down the pipes and performing other selfish actions. We have much to learn yet before we attach as much importance to public conveniences as people do in England. They are a necessity of existence, and their fittings and walls should be of the most approved hygienic patterns it is possible to obtain.

Rubbish bins are an essential in a public park. I am in favour of iron ones similar to those used by the Sydney Municipality, and which have been introduced into the parks under my control. In Europe baskets of all shapes and sizes are used for the purpose, but they become filthy, have an untidy appearance, and are readily injured. Iron bins of the kind referred to are readily emptied and cleaned and effectually preserve edible rubbish from being eaten by rats. Nevertheless it is a matter for regret that large numbers of people refuse to put scraps of paper and food-rubbish into any receptacle whatever, sometimes even displaying considerable ingenuity in depositing it on the grass, etc., when the attention of the ranger is directed elsewhere. This cross-grainedness in human nature is to be deplored, for the public parks cannot be kept in an ideal condition except by the active co-operation of the people themselves. The state of a public park as regards tidiness in a measure reflects the habits of the people themselves. A dirty, carelessly kept park points to a neglectful community.

3. *Water Supply.* Drinking fountains in public parks should be sufficient in number and should have an adequate water supply. Certain mischievous boys and other people delight in wrenching off the cups, damaging the spouts and injuring

fountains in various ways. In consequence, special arrangements have to be made to guard against wilful injury. Fragile fountains should have no place in a public park open day and night; this is to be regretted, because slenderness of construction is sometimes inseparable from an artistic object such as a fountain.

Some years ago the attention of the Board of Health was directed to the drinking fountains of Sydney and the Board stated:—

"It has been pointed out that large dogs and other animals drink from those which are so arranged that water remains in the cisterns under the drinking taps; and, as children and others drink from these instead of from the taps, and hydatid and other diseases are likely to be in this way propagated, the Board is very strongly of opinion—

1st. That wherever there are cisterns they should have a runaway at the bottom, so that no water can collect; and—

2nd. That cisterns for dogs should not be allowed in fountains placed near Public Schools, as it is found that young children drink out of them."

An adequate water supply is also necessary for the watering of roads, the flushing of gutters, the watering of plants (even large trees have to be watered during droughts), and various miscellaneous park services.

4. *Public baths and boat-sheds.* The matter of baths for the public is one of special importance to us in a semi-tropical climate. In the case of those parks at a distance from the water the matter of the erection of public baths, such as are seen in every large town in Europe, is a matter for consideration. In most cases, however, there is no special advantage in having baths in a park, while the objection to the erection of a building in a park when provision can be as well and even better made for it in a public thoroughfare, is one deserving of very serious consideration. But many Sydney parks have water-frontages to Port Jackson, and it seems desirable that, wherever possible, facilities should be given for utilizing a portion of

such water-frontage for public baths. I am of opinion that public baths can be provided for in most of our waterside parks, and buildings from which swimming contests can be viewed can be provided in a few instances.

Then I would provide every possible facility for the hiring of boats and for the accommodation of boating-clubs. At present boat sheds are usually ramshackle affairs, often half concealed from view on the park side, whereas the boat-wharves should be well in view, for the starting and return of boat-crews gives an element of picturesqueness which is very pleasing to park visitors. Let us be in touch with our boating citizens, for Sydney is a port and we are proud of our prowess on the water. Furthermore, to have well appointed places would encourage many people to indulge in the healthy recreation of a blow on the harbour who feel that few inducements are offered to them at present.

5. *Refreshments.* Unless a park has restaurants or refreshment rooms outside, close to its entrances, it is usually desirable to provide refreshment rooms or fruit-stalls within the park area. Permanent buildings should be of an ornamental character and there should be seats in the immediate vicinity for the convenience of people who desire refreshments in the open air. These seats should be under the control of the lessee of the refreshment room. Any citizen can claim to use a seat which is placed in a public park, but people as a rule do not press their rights where the seats are in the vicinity of a refreshment-room, and, when they bring their own food, they usually purchase tea or hot water from the lessee. The details of arrangements in regard to refreshments depend so very largely upon the special circumstances of every particular park that I do not propose to enter into them.

Besides the more substantial refreshment pavilion, of which there should be one in every large park, there is no doubt that the public convenience demands opportunities at the principal entrances of the large parks for the purpose of buying minor refreshments, such as biscuits and fruit, the former being largely used by the children for the delightful occupation of feeding the land-birds and water fowl. This should be encouraged not only because of the evident pleasure it gives children, but also of the lesson it teaches of kindness to animals. At present these small articles are purchased from moveable, rickety hand-barrows or fruit-stalls, but these should be replaced, wherever possible by small kiosks—permanent structures of artistic design.

b. *Luxuries:*—

1. *Games and Gymnasia.* I have put games etc. under the heading of luxuries, but personally I look upon them as absolute necessities. The games that are most commonly played are cricket and foot-ball. The former game is specially catered for at the Sydney Cricket Ground, Moore Park, and the latter at the Agricultural Ground. As regards the Outer Domain cricket is under the auspices of a small Trust, appointed in 1856, who employ a man for the purpose of keeping in order a small area known as the Cricket Ground. On other parts of the Domain, cricketing (mostly by boys) is permitted in so far as it does not interfere with the comfort of other citizens who desire to use the Domain.

In the Centennial Park every encouragement is given to outdoor games. A polo club has a ground allotted to it, and it is kept in order at the club's expense. Following are the special arrangements in regard to cricket and football respectively.

Cricket.—(1) Permits to play cricket are issued annually by the Officer-in-Charge, and must be applied for previous to the commencement of the cricket season in every year —usually towards the end of August. The permits are usually renewed from year to year provided no well-grounded complaints have been made against the conduct of members, and in the case of a wicket becoming vacant care is taken to apportion it to the club best entitled in point of numbers and age of members, giving where other things are equal the preference to a local club. (2) No charge is made for wickets. (3) All clubs obtaining permission to play cricket must join the Association formed by the clubs playing cricket in the Centennial Park. (4) Any alteration of grounds in the shape of levelling or top-dressing must only be made after the sanction in writing of the Officer-in-Charge has been obtained.

The Association referred to above is called the Centennial Park Cricket Association and consists of a number of clubs playing in the Centennial Park. Office-bearers of the Association are annually elected and further information may be obtained from a hand-book published annually by the Association which gives a list of office-bearers, rules, competition rules, fixtures, etc.

This Association during the playing season employs a man to keep wickets and ground in proper repair; further, the Association controls the letting of wickets, in this way preventing clubs from obtaining a wicket merely for money making; it also deals with the misconduct of any players belonging to clubs which are affiliated. The existence of the Association has been the means of improving the status of cricket in the Centennial Park, and of assisting the park officials in the control of both the players and the onlookers.

Football.—(1) Football permits are applied for and obtained in a manner similar to that observed for the

obtaining of cricket permits. They are usually issued early in the month of May in each year. (2) No charges are made for grounds. (3) No conditions in regard to joining an Association are insisted on for football clubs, but the clubs have each to mark out their own grounds, and find and erect their own goal posts.

Latterly gymnasia have been established both in the Outer Domain and in the Centennial Park. These are the first instituted in Australia, although in Europe they are common enough. The specification of the Domain gymnasium is as follows, that of the Centennial Park being nearly the same. I trust that we shall soon have them in everyone of our parks, particularly those that are situated in densely populated districts.

A range of six horizonal bars of different heights, and four sets of parallel bars for children of different ages. Two giant strides of eight ropes each. One set of five travelling rings. Four swings. Two trapezes. One climbing rope ladder. Two climbing ropes (one knotted and one plain). One sliding plank. One inclined ladder. Two see-saws. A sand heap for very young children, and a climbing pole or mast for the most venturesome, and which will also answer as a flag pole.

I have touched upon boating, an exercise that should receive every encouragement in Sydney, at p. 36.

2. *Music*. Commodious band-stands should be provided in every public park. The design of the band-stand should be artistic and in keeping with the park. If we want good music we must make the musicians comfortable, and hence a good band-master should always be consulted in the erection and furnishing of a band-stand. The band-stand should not be on a windy eminence; the sound passes away, while the musicians may be chilled and their sheets of music blown away. They should have Venetian blinds to protect them

from glare. Suitable seats and music-stands should be provided for the performers, also mugs or tumblers, and proximity to a good water supply. The lower portion of the band-stand should form a room for the storage of the seats, music-stands, etc.

Then seating accommodation for the public should be provided as far as possible. In our climate there is less necessity for seats than in wet and cold districts, if a nice grassy sward is available. Then it is impossible to provide fixed seats to accommodate all the listeners, otherwise that portion of the park, in the vicinity of the band-stand will, except during the period of a performance, have the appearance of a deserted cattle sale-yard. If there is a building in the park convenient for the storage of a large number of chairs, these might be brought out for each performance and returned at its close, but, in spite of the objections of people who want the Government to perform every petty service for them, I remain at present of the opinion that in most cases the best plan would be to arrange with a contractor to supply chairs for each performance, who would recoup himself by a charge of a penny a head, certainly not an unreasonable demand. This is a common practice in Europe, even in parks where one has to pay a fee to listen to the performance whether one stands or not.

3. *Statuary.* The question of the nude in art is one to which the custodians of public parks must give attention to at one time or another. When the matter is spasmodically dealt with in newspapers and professional journals, pictures in an art-gallery or advertisement posters have usually raised the points at issue. Then the matter is usually discussed from the life-class or artist's model point of view, while certain artists express themselves in emphatic terms, sometimes chiding the general public for possessing inartistic souls. No work in which the question of the

nude in art is discussed as regards public parks is accessible to me. In a public gallery the officials can readily make arrangements for restricting the view of a picture from those to whom it is considered undesirable to show it, whether it be young children, or mixed gatherings of both sexes, but in a public park art objects must be open to public view all day long.

We have very few objects in our Sydney parks to whom any person may take exception on moral grounds, but there are one or two in regard to which persons whose judgment should be respected have raised protests. My own view in this matter can be very simply expressed. There should be nothing in any public park to wound the susceptibilities of any citizen. A man should be able to pass through a park without seeing anything that will bring a blush to the cheek of his wife, his daughter, his sweetheart or any other woman or child. Further, there should not be any objects that require (so to speak) to be apologised for or slurred over, for an art object should not only not be a source of pain or discomfort to some, but it should be a source of pleasure,—an aesthetic ideal maybe, to all.

I am sorry to say that there are so few statues or other art objects in the Sydney parks, exclusive of those (Botanic Gardens and Garden Palace Grounds) that are closed at night. Most of the statuary is to be found in the Centennial Park and Hyde Park. Although creditable for a young country, candour compels one to admit that much of it does not reach a very high standard of art.

Statuary in public parks is often looked upon as a target for mischievous people and one has to frequently repair it. In consequence art objects of considerable value cannot be exhibited in a public park unless they are practically proof against wilful damage or unless they can be specially protected.

Of course such objects as fountains and national memorials of various kinds may be artistic in character and suitable adornments for a public park. But they should be few in number and have suitable settings.

POSSIBLE RELATION BETWEEN SUNSPOT MINIMA AND VOLCANIC ERUPTIONS.

By H. I. Jensen.

(Communicated by Prof. David, B.A., F.R.S.)

[With Plate II]

[*Read before the Royal Society of N. S. Wales, June 4, 1902.*]

During the past three months the world has been startled by a series of volcanic and seismic phenomena, which, in point of extent and violence, are almost unparalleled. Within a few months we have heard of a great earthquake at Cheviot, in New Zealand, synchronous with a violent volcanic eruption in the Kermadec Islands. This was succeeded by a violent earthquake in Transcaucasia that ruined numerous towns. Then came the West Indian earthquakes accompanied, or rather followed by the eruptions of Mount Pelée, La Soufrière and Mount Tacoma, and synchronously great earthquakes devastated ten cities in Guatemala. Since then we have heard of a succession of rumblings in the Auvergne district of France, an area spotted with extinct volcanoes ; a serious earthquake at Corfu, another near Paris; and lastly we hear that Mount Redoubt in Alaska is in violent eruption, and that poisonous gases are issuing from Mount Trabochetto, an extinct volcano between Genoa and Nice.

At the time of the Baku and Transcaucasian earthquakes I read up some facts about European volcanoes and earthquake areas, and in connection with Vesuvius I noticed that it was in violent eruption approximately every eleventh year. This being the well known sunspot period I started on a further enquiry. Late in the fifties of last century, four distinguished scientists Julius Schmidt, Wolf, Kluge, and Poey had discussed a probable relation between volcanic and sunspot phenomena.

Schmidt came to the conclusion that there was no marked coincidence between *the appearance of sunspots* and earthquakes, though, as far as can be gathered, he did not investigate the converse, namely, whether there is any connection between the phenomena of absence of sunspots and the occurrence of violent shakings on the earth.

M. R. Wolf, a distinguished authority on sunspots and earth magnetism, considered that earthquakes and volcanic eruptions were *coincident with sunspots.*[1] He apparently only theorised on the subject instead of investigating facts, which, if studied, would speedily have disillusioned him.

Kluge, a noted authority on earthquakes, after a careful study of seismic disturbances in various parts of the world between 1850 and 1857, came to the conclusion that when there are few sunspots, earthquakes, volcanic eruptions and magnetic disturbances have been at a maximum. Though later researches have proved him to be wrong as far as magnetic disturbances are concerned, I hope to-night to prove him right in regard to volcanic and seismic phenomena.

M. H. Poey, who examined a catalogue of West Indian and Mexican earthquakes between 1634 and 1870, shows[2] that earthquakes have come in groups, first at maxima,

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[1] Bern. Naturf. Gesellschaft, 1852. [2] Comptes Rendus, 1874.

then at minima periods of sunspots. Out of thirty-eight groups he found that seventeen occurred at maxima and seventeen at minima, the remaining four being intermediate.

As unfortunately I have not been able to consult the papers of these four authorities, I have had to rely on Milne's "Earthquakes" for this information. Milne and all subsequent writers on this topic, reject the opinions of Kluge and Poey, on the ground of insufficient evidence. Lapparent and other modern writers on geology, do not even touch upon the question.

Undoubtedly the conclusions contradict one another. The latter investigations of Schmidt proved Wolf to be wrong. Poey shows that earthquakes occur both at maxima and minima, which certainly is so, but Kluge alone tries to demonstrate that they predominate at sunspot minima. Here it will be necessary to point out that if the results of these investigators are contradictory, it is not to be marvelled at, considering that we have no great abundance of information on sunspots before 1833, that the sunspot period may vary from nine to thirteen years, and that the dates of maxima and minima before that time have been obtained by calculation from a formula which may yet be shown to be incorrect. At the present time we have more data, sunspots have been closely observed for the last sixty or seventy years, and those who desire to see the exact sunspot curve from 1834 to the present, may find it in a paper by W. J. S. Lockyer.[1]

The sunspot curve on my chart is the one constructed by Mr. H. C. Russell from observations conducted in India. It does not show all the variations, ups and downs, that actually take place, but is made by joining the years of maximum and minimum sunspot activity by straight lines. Now, on looking at *Plate* II., we must not suppose that the

[1] Monthly Notices of the Royal Astronomical Society, Dec. 13, 1901.

object of the chart is foiled, because we see several groups of earthquakes, apparently coinciding with sunspot maxima. Thus, in 1789, there was an eruption of Kilauea; in 1829 a great Chilian earthquake; in 1839 an earth movement at Lemos, in the Chonos Archipelago, which resulted in an elevation of the island of eight feet; in 1850 we find an earthquake at Honduras, and then the great anomaly of 1883, of which more anon.

All that I desire to prove is that maximum seismic activity is coincident with sunspot minimum, and *vice versa.* This, it appears to me, the chart sufficiently shows. In fact, just as the sunspot curve shows a slow fall to a minimum and a sharp rise to a maximum, so does the earthquake curve show a slow rise to a maximum, and a sharp fall to a minimum. The earthquake and volcanic curves show most irregularity in the period between 1878 and 1890. A similar irregularity (less marked on account of paucity of records) occurred thirty-five years before in the period 1843 to 1854. The period 1878 to 1890 I propose to discuss in detail, to show that even here the seismic phenomena agree in smallest details with the phenomena of sunspots.

From 1870 the sunspots decreased steadily to a minimum in 1878. If we look at Lockyer's curve for the succeeding period, we find that instead of the usual sharp rise to a maximum, there was a very gradual rise, culminating in April 1882, in a remarkably fine spot accompanied by vivid auroral displays in our atmosphere.[1] Then there was a sudden falling off in solar energy in 1883—almost to a sunspot minimum—and then a rapid rise to the real maximum in 1884. This maximum lasted through 1884, 1885 and the greater part of 1886, when there was a rapid falling off to a minimum in 1888-9. During this period there was at no time a lasting maximum.

[1] See Monthly Notices, Royal Astronomical Society, Vol. L., p. 8.

The total spotted area for the period 1879.80 to 1890.2 was 78,253 in millionths of the sun's disc, as compared with 96,734 for the period 1890.2 to 1900.0, and 126,188 for the period 1867.2 to 1879.[1] We find the sunspot period between 1884 and 1889 divided as follows:—a maximum lasting from 1884 till June 1886, and a minimum from October 1886, culminating in June 1889.[2]

Now on looking at the earthquake records for these years we find great volcanic activity between 1876 and 1881, a marked falling off in 1882, a most abnormal increase in 1883, and almost total absence during 1884-5, and a renewed activity in 1886, comprising the Tarawera eruption in 1886 and the Bandaisan eruption in 1888. Thus for this period the volcanic outbursts seem to have corresponded pretty closely with extinctions of sunspots.

Similarly, the period 1892 to 1895 was one of great sunspot activity; in 1896 there was almost a minimum of sunspots, coincident with which a severe earthquake, predicted by Falb, was experienced at Zante. Renewed sunspot activity obtained from the end of 1896 till 1899, and an almost total absence of spots between 1900 and the present time.

Looking at the chart we may notice in particular how the eruptions of Vesuvius occur, this being a particularly sensitive volcano. Notable outbursts occurred in 1818, 1822, 1855, 1867, 1872, 1889, 1891, 1900. Of these years all are of sunspots minimum except 1872, which marks a sharp dip on an otherwise gradual fall to a minimum,[3] and 1813 which occurs very near the minimum of 1810-2, and is doubtful.

Studying the outbreaks of Mauna Loa, we find the severest to have taken place in 1789, 1822, 1833, 1852, 1867-8, 1877,

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1 See Lockyer, *op. cit.*

2 Memoirs ot the Royal Astronomical Society, Vol. L., 1890-1.

3 Journ. Roy. Soc. Astro. Soc., Dec. 13, 1901.

1887, all, except 1852 perhaps, minimum years. Those of Java were most severe in 1822, 1833, 1843, 1852, 1874-1878,[1] 1883. Those of Hekla were most noticeable in the minimum years 1783, 1843, 1875; those of La Soufrière in the years 1812 and 1902, and of Mount Redoubt in 1867 and 1902. The eruptions of Vesuvius are apparently also as a rule contemporaneous with a particularly fine corona, such as usually occurs in minimum years.

Milne mentions that at Copiapo the people expect a great earthquake once in every twenty years, at Lima every hundredth year, great devastating earthquakes having occurred in 1578, 1678, 1778, 1878, two of these actually taking place at the same hour on the same day.

The reason why all outbursts do not occur at sunspot minima is plainly that other causes are also at work in locating the time and place of volcanic outbreaks in addition to the chief agent above mentioned. There are perhaps some purely terrestrial causes, such as chemical action; the moon's influence is not to be ignored, and there is also planetary attraction. One great *immediate* cause of an earthquake may be the sudden relief of atmospheric pressure by the passage of a vast cyclone over an area. A sudden increase of pressure might start a volcanic eruption. However, in connection with these matters it will be as well to quote the views of some well known authorities.

Mallet observed that in European regions seismic minima seemed to coincide with barometric minima.

M. Alexis Perrey investigating the moon's influence found that out of 5,388 earthquakes studied by him, 2,761 or 51%, occurred at syzygies, and 49% at quadratures. Lapparent in his Géologie, whilst admitting the correctness of M. Perrey's research, considers the difference too trifling to found a law upon.

[1] The eruptions of Le Kaba in Java,

According to the statistics of Julius Schmidt of Athens, who studied the earthquakes between 1770 and 1873, seismic disturbances were more frequent when the moon was in perigee than at apogee. Lapparent, commenting upon this, makes a further assertion that studies on oriental earthquakes reveal the fact that when the earth is nearest the sun shocks are most frequent.

Fuchs shows that earthquakes are more frequent at equinoxes than at solstices (see Milne). The cause of this seems to me purely meteorological—more sudden changes of pressure taking place at the equinoxes.

According to Milne, a Japanese work, "Jishin Setsu," by a priest named Tensho, states that earthquakes depend upon the relative position of the moon with respect to twenty-eight constellations.

Professor Falb of Vienna also gained great reputation some years ago by predicting some earthquakes. Unfortunately he seems to have based his forecasts entirely on the motions of the moon, and therefore soon made some most incorrect predictions. For the year 1898 he forecasted great eruptions and a tidal wave which would wreck New York. As a matter of fact this year (1898) was a very quiet year.

By taking all factors into consideration it should however be possible to predict earthquakes. Primarily secular contraction is admitted to be the cause of all earthquake and volcanic phenomena. But this contraction is constantly going on, and if it were not modified by other causes, we should not have any grouping of seismic phenomena together into particular periods, years or seasons. The modifications must be caused by other factors hitherto neglected.

The factors to be considered in predicting earthquakes seem to be:—(1) Lines of weakness and faulting in the earth's crust; this factor locates places likely to be dis-

turbed. Geologists of the last thirty years have paid special attention to this matter, and the result is that a vast stock of information on the subject is available, forming a solid basis for the science of seismology of the future.

(2) The second factor in point of importance seems to be "absence of sunspots,"—the actual relations of a sunspot minimum to an earthquake maximum will need to be studied for several decades yet, before properly understood. Sunspot minima seem however to fix the periods in which great eruptions may be expected.

(3) To fix the season or month also falls within the realms of astronomy, as here the position of the earth with regard to the sun, and of the moon with regard to the earth must be considered, as well as the attractions of the nearer planets Venus and Mars.

(4) Lastly to fix the exact days, if it ever becomes possible, is likely to become an adjunct to the science of meteorology, as here cyclones and pressure changes are to be considered.

The Possible causes of Interdependency of Seismic activity and Sunspots.

Assuming that there is such an interdependency, what may be the possible cause or causes? Here it is only possible for me to enunciate some facts and to suggest a few theories for consideration.

Prof. Hazen, the American meteorologist, Dr. Köppen, Dr. Hahn (of the Sonnblick Observatory, Austria), the English meteorologist Alexander B. McDowall, and many others, working on similar lines, have noticed a decided connection between climate and sunspots. McDowall's researches are given in a paper read on April 21st 1897.[1]

Most German and Indian meteorologists have noticed a a similar connection; they are of the opinion that rainfall

[1] Quart. Journ. Roy. Met. Soc., Vol. XXIII., p. 243 – 250.

very largely depends on solar conditions, being large at sunspot maxima, deficient at sunspot minima; some also believe that the mean atmospheric pressure is somewhat increased during minimum years and diminished in maximum years.

Before proceeding it might be well to mention that meteorologists are by no means unanimous on this question, but if a connection between sunspots and climate can be definitely proved, it is reasonable to suppose that earthquakes which are known to be influenced by weather are also influenced at any rate indirectly by sunspots.

According to Professor Schüster "the difference between the average temperature in years of maximum and years of minimum amounts to the considerable amount of 0·73° C. in tropical, and over 0·5° in extra-tropical parts of the world; and Gautier has shown that the temperature curve displays the same characteristics in period as the sunspot curve."[1]

Carpenter and Balfour Stewart found "that sunspot inequalities, whether apparent or real, seemed to have nearly the same periods as terrestrial inequalities as exhibited by the daily temperatures at Toronto and Kew."[2]

Mr. Blandford's observations in India, as well as spectroscopic investigations by Roscoe and Balfour Stewart, show that solar radiation in years of sunspot maximum is greater than in minimum years.

The great Austrian meteorologist, Hahn, has paid special attention to abnormal temperatures, and has observed that the summers were hotter at or near a time of sunspot minimum, while colder and wetter summers and winters obtained at a maximum.

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[1] Article by Professor Schüster in "Report of Brit. Assoc. for the Advancement of Science, 1884."

[2] See Schüster and also Rev. A. L. Cortie's paper on "Sunspot Spectra"—Memoirs Roy. Astro. Soc., 1890-1, Vol. L.

Professor Piazzi Smith noticed a remarkable eleven year period in the temperature curve for Carlton Hill.

German scientists of distinction, such as Prof. Foerster of Berlin, and Rudolph Mewes, believe that the rainfall is excessive in years of sunspot maximum and deficient at minima, owing to more heat being received from the sun at sunspot maxima.

Lockyer says,—"It is generally conceded that the spots on the sun are the result of greater activity in the circulation of the solar atmosphere, and therefore indicate greater heat, and consequently, also greater light production." In the same writer's interesting paper in "Monthly Notices" of Royal Astron. Soc., Dec. 1901, we find a reproduction of curves constructed by Mr. Brückner, which show a similar variation extending over a period of thirty-five years, in climatic, magnetic and sunspot conditions. There seems to be some law at work which retards the sunspot maximum in relation to the approaching minimum, resulting in similar conditions and similar curves every thirty-fifth year.

The close connection between solar and terrestrial phenomena was summarised as follows by W. Ellis in Phil. Trans. 1880:—(1) The diurnal ranges of the magnetic elements of declination and horizontal force are subject to a periodical variation, the duration of which is equal to that of the eleven year sunspot period.

(2) Epochs of maximum and minimum sunspot effect are nearly coincident with periods of maximum and minimum magnetic effect, and the variations in the duration of the different periods is nearly the same.

(3) Occasional outbreaks of violent sunspot and magnetic energy often several months in duration, occur nearly

simultaneously, and disturbances of the earth's magnetic condition are accompanied by Aurora Borealis displays."[1]

Wolf and Fritz suggested that in addition to the eleven year period there was also a period of longer duration (which they thought to be fifty-five years) in the sunspot and magnetic curves. Later researches by Brückner, Lockyer and others show this period to have a duration of thirty-five years. In this connection it is important to notice that Wolf found a secular variation in climatic conditions in Europe with a period of about thirty-five years.

On looking at the diagram (*Plate* II.) we also observe traces of a thirty-five year period. Thus violent outbursts of volcanic energy after a considerable lull occurred in 1867 and the present year. The groups centered around 1822, 1855 and 1889, are less well defined than the others. Mount Redoubt in Alaska, was in eruption in 1867 and again in 1902.

Before proceeding it will be as well to point out that Mr. Meldrum found the number of severe cyclones in the West Indies, in years of sunspot maxima, to exceed the number in minima. Blanford's observations in India (1848–1876) show that the maximum pressure occurs in minimum sunspot years. These two facts seem to show that anticyclonal conditions in the earth's atmosphere are most prevalent with a sunspot minimum, and cyclonal conditions with a maximum. Mr. H. C. Russell points out in "Periodicity of Good and Bad Seasons" that violent hurricanes come in droughts. Now these facts are quite in accord, for anticyclonal conditions would lead to droughts, and when anticyclone follows anticyclone, cols would be frequent, and the breaking of these cols would give rise to violent hurricanes.

Finally we come to the possible causes of the dependence of earthquakes on sunspots.

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[1] Milne observes that particularly fine auroral displays have on a few occasions been accompanied by earthquakes—"Earthquakes," p. 264). This however seems only to be exceptional.

(1) The most likely theory seems to be that at sunspot minimum, when less energy is received from the sun, the earth cools quicker and radiates more heat and perhaps magnetism into space. The radiation of heat would be further favoured by the absence in the atmosphere of the usual protective canopy of moisture. When this rapid cooling is progressing, there will obviously be more contraction, hence cracking, in the earth's crust, and consequently more earthquake shocks.

The strongest objection to this theory is the fact that the passage of heat through rock is a slow process, and that electrical radiations are also supposed to be checked by passing through a layer of rock. But if we give credence to statements lately made, that the Marconi electrical waves can pass directly through a mountain, the difficulty is lessened. For then it would appear that some of the solar rays might have the power to pass through the solid rock, and that the earth would be able to send out similar radiations. These radiations in making their escape might be partly transformed into heat at points where resistance is offered, as at the fissures in the earth's crust. From accounts of great earthquakes and eruptions it certainly seems that there is a great evolution of electricity or magnetism as well as heat, accompanying the phenomena.

(2) Another possible explanation of this connection between solar physics and seismic phenomena, is that the atmosphere by contraction and increasing its pressure at the earth's crust, exerts a squeeze on the earth's crust. This makes itself most felt at the lines of weakness, where lavas are consequently squeezed out through volcanic vents, or up into zones of no strain thus causing earthquakes.

(3) Alterations in magnetic conditions may have something to do with causing earthquakes. A friend of mine who was serving on board an American man-of-war in 1868,

tells me that during the St. Thomas earthquake of that year, all the ship's compasses ceased to act, only regaining their powers a few hours after.

Milne, in "Earthquakes," mentions that before the great Japan earthquake in 1855, the owner of a spectacle shop in Asakusa noticed that his magnet had lost its strength, which it only regained a few hours after the shock.

There are also a few subsidiary causes, or possible causes worthy of notice. The lessened atmospheric temperature in years of sunspot minimum is quite sufficient to cause a great accumulation of ice at the earth poles. This change of load, increase in cold, decrease in warm regions, may favour volcanic action in tropical regions.

In conclusion I desire to express my heartfelt gratitude to Professor David for the great assistance he has given me in compiling this paper, by lending me books, giving me access to libraries and suggesting matters, and in bringing this paper before the Royal Society. My thanks are also due to Mr. H. C. Russell for his kind and valuable assistance.

Explanation of Chart.

The earthquakes between 1780 and 1902 fall into eleven groups, called α, β, γ, etc., respectively, α being the most recent. The α group comprises the earthquakes and eruptions between 1900 and 1902 (inclusive). The β group includes those around the minimum of 1888-9; the minimum began in 1886 and ended in 1891. The γ group 1876—1881; δ 1865—1869; ϵ 1852—1857; ζ 1843—1846; η 1832—1835; θ 1819—1828; ι 1810—1813; κ 1797—1799; λ 1783.

Any large eruption or earthquake is given a space on the chart, very large ones are given twice as much space as smaller ones, and exceptionally severe seismic phenomena are alloted three times as much. Minor activities, too important to be omitted and yet not important enough to

get an entire space, are given a half. Only Krakatoa and Bandaisan are alloted three spaces each. In other places where large columns of three or four spaces appear, they are composed of several severe (or widespread) eruptions or earthquakes.

The earthquakes are numbered (with a few exceptions), and the eruptions lettered. I do not deem it necessary to describe the eruptions or earthquakes of each group, but an index to the chart is appended. Eruptions of Vesuvius are lettered V, those of Etna E, those of the Sandwich Islands K, and so on. As regards earthquakes the same numbers are used again in each group but with no special significance.

The sunspot curve has been taken with Mr. Russell's permission, from his paper[1] on "The Periodicity of Good and Bad Seasons," but it is inverted so as to bring the minima on top. The part of the curve between 1892 and 1902, I constructed myself from data obtained in "The Observatory" for 1898, and the Journ. Royal Astron. Soc. Fine solar coronæ are seen at every sunspot minimum. These are denoted on the chart by columns placed under the sunspot curve. In 1882-3 there was a very extensive corona, accompanied however by some prominences of great magnificence.

The most noticeable instances of seismic phenomena not coinciding with the groups are—(1) Earthquakes of importance in 1815, 1828-9, 1840, 1847-8, Mendoza 1861. (2) Eruptions in 1829, 1840, 1847, 1870-2. In the index are enumerated all the earthquakes and eruptions for each year since 1780.

The following table gives all the eruptions of Vesuvius, Etna, (and of a few other sensitive spots) that are reported

[1] Journ. Roy. Soc. N. S. Wales, xxx., 1896, p. 70.

in text books. Those that are not contemporaneous with a sunspot minimum are marked with an asterisk:

Vesuvius.	Etna.	Mauna Loa.	Kilauea.
1776 – 1779*	1811	1832	1823
1794	1832	1852*	1832
1813	1843	1855	1840*
1822 – 3	1852*	1859*	1855
1855	1855	1877	1868
1858 – 1860*	1858	1877	1868
1865 – 1867	1865 – 7	1880	1879
1872*	1879		1891
1877	1883		
1889 – 1891			

INDEX TO CHART.

DATE.	EARTHQUAKES.	ERUPTIONS.
1811	Shocks in Europe; Mississippi earthquake (1) ...	Etna (E), Azores (A).
1812	„ „ (3); Caracas (2)	La Soufrière (L).
1813	... ...	Vesuvius (V).
1815	... ...	Tombora (Java)*
1818	Chili (5)	Jan Mayen (c)
1819	Cutch (4), Copiapo, Chili (5)	Bogoslow (d)
1820	La Banca (3)	
1822	Java (1), S. America (2), Valdivia, Valparaiso, Santiago	Vesuvius (V), Galongoon (b).
1823	Hawaii (6), Fahlun and Presburg (7)... ...	Vesuvius (V), Kilauea (K).
1827	Popayan-Bogota (8)	
1828	Lima (9)	

Index to Chart.

Date.	Earthquakes.	Eruptions.
1829	Santiago (Chili) (10)	
1831	... ...	Pantellaria (P)
1832	Huasco (6)	Mauna Loa and Kilauea (K), Etna (E), Vesuvius (V.)
1833	England (1), Peru (2)	Vesuvius
1834	Nepaul and Ganges (3), Pasto (4)	Pasto (*b*).
1835	Chili (5)	Cosequina (C).
1837	Safed (Palestine) and Chili shocks.	
1839	Lemos.	
1840	Sandwich Islands	Kilauea (K).
1843	Ischia (1), Hawaii (2), Iceland, Guadelope (4), Java (3)	Iceland, Mt. Katla (Hk); Goentoer, Java (G).
1844	... ...	" " (Hk).
1845	... ...	" " (Hk); Orizaba (O).
1846	Rhineland.	
1847	Senkoji.	
1848	New Zealand	Popocatopetl (P), Le Keloet, Java (LK).
1850	Pesth and Heliopolis (13), Honduras (?) (14).	
1852	Smyrna (11), Hawaii (10)	Mauna Loa (K), Komaga (J)
1854	Acapulco (9), Japan (12)	Simoda (S).
1855	N. America (5), California (6), Broussa and Japan (2 and 3), New Zealand, Germany (1), France and Switzerland (4)	Vesuvius (V), Kilauea and Mauna Loa (K).
1856	Siberia (7), Honduras (8), Naples	Colima (C)
1857	Naples and Sicily (15).	
1858	... ...	Etna (E), Vesuvius (V).

Index to Chart.

Date.	Earthquakes.	Eruptions.
1859	... ...	Vesuvius (v) continued to 1860; Mauna Loa (K)
1860	.. ..	Katla, Iceland (I).
1861	Mendoza (earthquake and fissures).	
1865	Lima (8)...	Etna (E).
1866	Kaimenis (9)	Santorin (S).
1867	Kansas (1)	Vesuvius (V), Azores (A).
1868	St. Thomas (2), San Francisco (3), Equador (4), Arica (5), Tanna (6), Sandwich Island (6)	Kilauea (K), Teleki Africa, Etna (E), El Misti (M).
1869	Cachar (7)	
1870	.. ..	Colima (C).
1871	Oahu	Cameguin (Ca).
1872	... ...	Vesuvius (V), Colima (C).
1873	... ...	Etna (E), Stromboli (St) and Colima (C), intermittent.
1874	Austria (Herzogenrath), France and Italy (15 and 13), Iceland (16)	Stromboli (St), Aso-Yama (J), Iceland (I).
1875	Java, Martinique (12), Tanna and Loyalty (11), Iceland, New England (14)	Etna (E), Java, Le Kaba (LK), Iceland (I).
1876	Herzogenrath (*h*)	Le Kaba (LK), Cerboruco (Ce).
1877	Copiapo and Iqique (3), Herzogenrath ...	Le Kaba (LK), Cotopaxi (Co), Mauna Loa (K).
1878	Lima (1), Peru and Equador (1), Port Resolution and Tanna (2), Blanche Bay (New Britain) (2), Battang, China.	
1879	San Salvador (4), Iceland	Etna (E), Stromboli (St), Kilauea (K), Iceland (I), Ilopango (M).
1880	Yokohama (5), Philippines (5), Hawaii ...	Mauna Loa (K).

INDEX TO CHART.

DATE.	EARTHQUAKES.	ERUPTIONS.
1881	Ischia (6), Chios (6), Philippines (7), Japan (7)...	Colima (C).
1882	Tokio (8).	
1883	Cassamiciola and Ischia (9), Tokio (10), Malaysia (11	Krakatoa (*b*), Etna (E).
1884-5	Shocks in Andalusia	Le Semeroe (Java, J), Mt. Augustin (Alaska).
1886	Charleston (5), New Zealand, New South Wales, Tarawera (*a*), shock in Liguria ...	Tarawera (*a*).
1887	Liguria and Riviera (1), Tarawera (2), Hawaii (H)	Kilauea (K), Mauna Loa (K), Stromboli (St).
1888	Tanna (3), Christchurch (3), Japan (4) ...	Bandaisan (*b*), Stromboli (St).
1889	Koumanoto I. (Japan)	Stromboli (St).
1890	... ...	
1891	Midori (7), New Zealand and Tasmania ...	Vesuvius (V), Kilauea (K), Colima (C), Pantellaria (P).
1892	Sanzel and Burmah (8 and 9).	
1893	Nelson, New Zealand (10)	
1896	Zante (*x*).	
1900	Maulapao (5)	Vesuvius (V).
1901-2	Cheviot (1), Baku (2), Guatemala (3), West Indies (3), Florida (3), Corfu (4), Paris (4)	Mt. Pelée, La Soufrière, Kermadec I., Mt. Redoubt, Mt. Tacoma.

NOTE—The disturbances represented on the Chart between 1780 and 1810 are:—

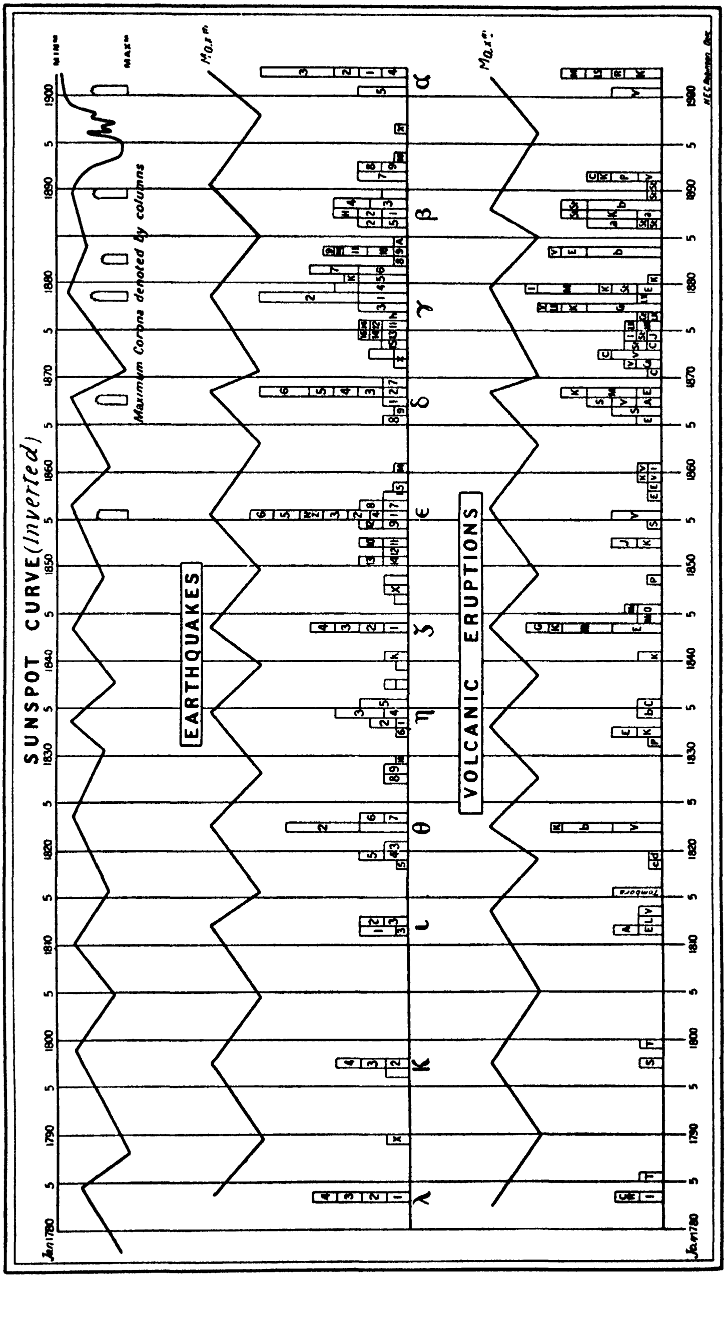
1783 Reikjanes, Iceland (1), Asima, Japan (2), Calabrian earthquake (3), Irasu eruption (4), Costa Rica earthquake (4).

1785 Teneriffe eruption (T).

1789 Kilauea earthquake and eruption.

1797 Cumana (2), Copiapo (3), Riobamba (4), Pasto eruption (5).

1799 Teneriffe eruption (T).


SUNSPOT CURVE (Inverted)
Maximum Corona denoted by columns
EARTHQUAKES
VOLCANIC ERUPTIONS
Jan 1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900

NOTES ON TWO CHEMICAL CONSTITUENTS FROM THE EUCALYPTS.

By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum.

[*Read before the Royal Society of N. S. Wales, July 2, 1902.*]

(1) GERANYL-ACETATE ($C_{10}H_{17}OOCCH_3$).

In November 1900, the announcement was made to this Society, of the occurrence of this important ester in the oil of the "Paddy's River Box," *Eucalyptus Macarthuri*, Deane and Maiden, from which species it was obtainable in commercial quantities. The results of the investigation were published in the Proceedings for 1900, Vol. XXXIV., p. 142. Since that time a considerable amount of work has been done on the oil of this species, distilled at various times of the year, and some interesting results have been obtained.

The comparative constancy of constituents occurring in the oils of identical species of Eucalyptus, is a fact of considerable economic value, and although the naturally formed ester in the oil of *E. Macarthuri* varies between 60 and 75 per cent., yet, it is found that this variation is between the constituents themselves which are always present in the oil; accordingly when the ester (geranyl-acetate) is more pronounced, then the free geraniol is correspondingly less. Samples of the oil distilled during several months of the year show the minimum ester content to be about 60 per cent., and it has not been found that the ester present falls below the amount stated in the original paper. Although the ester content reached 74·9 per cent. in the month of September, yet this was entirely geranyl-acetate, and the saponification was complete in the cold, after two

hours contact, using alcoholic potash. This method of cold saponification is important, as the reaction is complete, and the quantitative results certain. Duplicate and triplicate determinations have been found always to agree within the errors of experiment. The results, so far, show that the minimum standard of 60 per cent. of ester might be insisted upon, for the oil of this species, at any time of the year. The oil of this Eucalyptus does not appear to contain phellandrene at any time, so that its detection would indicate sophistication with the cheaper phellandrene oils. Undoubted samples of the oil of *E. Macarthuri* do not contain Eucalyptol, so that the detection of this constituent would also cause suspicion. The most valuable constituent in this oil is, of course, geranyl-acetate, so that any admixture with inferior oils would at once diminish its value; but the detection of adulteration is exceedingly easy, as not only would such a mixture be at once detected, but the group of Eucalypts from which the added oil had been derived could also be determined.

In Messrs. Schimmel & Co's price list for January 1902, the oil of *Eucalyptus Macarthuri*, containing 80 per cent. of geranyl-acetate, is quoted at twenty-four shillings per pound. The oil of this species does not contain this amount of ester at any time of the year, so that if this standard is maintained it would be necessary to acetylise the free geraniol occurring in the oil, or else to add the necessary amount of geranyl-acetate to it. Geranyl-acetate is quoted in the price list above referred to at forty shillings per pound.

During the greater portion of the year the oil of *E. Macarthuri*, after acetylising, would show the presence of 80 per cent. of ester, and often a little over that amount, the extra ester having been obtained from the free alcohol present in the original oil. It is perhaps remarkable, that

the original sample of the oil of this species should have shown a less amount of both ester and free alcohol than has been obtained with any sample since. From numerous determinations it has been found that as the naturally formed ester increases in amount, the free alcohol correspondingly diminishes. In the sample in which 74·9 per cent. of ester was found, only a comparatively small amount of free alcohol was present, the acetylised oil only containing 82·6 per cent. of ester, showing only 6 per cent. of free alcohol in the oil at that time. Another sample containing 65·8 per cent. of naturally formed ester, on acetylising gave 80·5 per cent. of ester, indicating the presence of 11·5 per cent. of free alcohol. It is thus apparent that the free alcohol is greater in the oil when it contains the less ester. In all the determinations that I have, so far, been able to make, the ratio $\frac{\text{combined geraniol}}{\text{total geraniol}}$ ranges between $\frac{80}{100}$ and $\frac{90}{100}$.

The following investigation was made upon a quantity of oil distilled by the Australian Eucalyptus Oil Co., from *Eucalyptus Macarthuri*, during May last, and from the results of which it can be seen that uniformity, within certain limits, is obtainable with the oil of this species, and that it follows the general rule in this respect. In appearance and odour the crude oil was identical with previous samples, and both phellandrene and Eucalyptol were absent. Eudesmol, although easily detected, was present in less amount than usual, consequently the specific gravity was correspondingly low, in fact, it was lower than that of any other sample investigated. The optical rotation was but slight, and to the right, so that the oil is always slightly dextro-rotatory, as all the samples so far tested have shown that peculiarity.

Specific gravity at 15° C. = 0·9174
Specific rotation $[\alpha]_D = + 0{\cdot}763°$

Ester determination:—

2·0181 grams. required 0·3948 gram. KOH, giving a saponification number of 195·6, equal to 68·43 per cent. of geranyl-acetate.

2·308 grams. required 0·4508 gram. KOH, giving a saponification number of 195·3, equal to 68·35 per cent. of geranyl-acetate.

A portion of the oil was then acetylised by boiling with acetic anhydride and anhydrous sodium acetate in the usual manner:—

1·996 gram. of this esterised oil required 0·462 gram. KOH, giving a saponification number of 231·5, equal to 81·025 per cent. of geranyl-acetate.

As 68·4 per cent. of ester occurred naturally in the oil, the amount of ester formed with the free alcohol was 12·025 per cent. If this alcohol is considered to be entirely geraniol, with a molecular formula $C_{10}H_{18}O$, then the amount of free alcohol in this sample of oil was 9·92 per cent., and the ratio of $\frac{\text{combined geraniol}}{\text{total geraniol}}$ is $\frac{84}{100}$.

Messrs. Schimmel & Co. have also determined this interchangeability between the ester and free geraniol, the results obtained by them on two consignments (private communication) being as follows:—

(1) Ester content before acetylising = 63·7%; after 85·2%.
(2) ,, ,, ,, = 71·68%; ,, 80·5%.

In the semi-annual report issued by this firm, April 1902, page 38, is published further results obtained with sample No. 2. The crude oil was submitted to rectification in vacuo when of course the eudesmol and other higher boiling constituents remained in the still. The rectified oil had an ester content 73·95 per cent., and although the oil had been but little altered in its general properties, yet, the rectification had improved the odour considerably.

On acetylation, the ester content was found to be 82·2%, whereas the crude oil only gave 80·5% of ester on acetylation, thus indicating that the greater portion of the free alcoholic bodies had been recovered in the rectification.

In an interesting series of experiments carried out by MM. Charabot and Hébert, "on the mechanism of esterification in plants," and published in the Scientific and Industrial Bulletin of Roure-Bertrand Fils of Grasse, Oct. 1901, it is shown that the maximum ester content obtained with geraniol and acetic acid, by the method of experiment adopted, was reached when the $\frac{\text{combined geraniol}}{\text{total geraniol}}$ equalled $\frac{67}{100}$, but it is rarely that this ratio in the naturally obtained oil from *E. Macarthuri* falls below $\frac{80}{100}$. This high ester content for naturally combined geraniol, is another instance of the exceedingly interesting nature of the problems submitted by the members of this wonderful genus, because if the process of esterification of the terpene alcohols takes place in the chlorophyll bearing organs as supposed, it seems somewhat remarkable that in no other species of Eucalyptus so far investigated, has this ester been detected in quantity, and the appearance of the tree of *E. Macarthuri* is a typical Eucalyptus, in its suckers, its bark, its leaves, its buds, and its fruits, and the constituents of its oil are always of the same character. Nor is it the presence of an increasing amount of acetic acid in the oil of this species that is answerable for the formation of this ester, because in the oils of some species (*E. umbra* particularly) a large amount of acetic acid is present in combination as an ester, but the alcohol is not geraniol. With the exception that *E. Macarthuri* belongs to the same natural order as *Darwinia fascicularis*, *i.e.*, the Myrtaceæ, there is little resemblance between these two plants, but the oils obtained from them are almost identical as regards the ester. If then the esterification in plants is brought about by the

direct action of the acids upon the alcohols, and is assisted by a special dehydrating agent, as suggested by the above authors, the question arises as to what this special agent is that brings about the formation of this ester in the oil of *E. Macarthuri* alone of all the Eucalypts. It may be suggested that the reason is because geraniol is the most abundant alcohol in this species of Eucalyptus. The comparative absence of this terpene alcohol in the other members of this genus is thus difficult to understand, and the whole problem respecting the four esters now known to exist in Eucalyptus oils thus becomes one of exceeding interest, and worthy of special scientific study.

(2) MYRTICOLORIN.

In a paper[1] on the chemistry of the dye-material Myrticolorin, discovered by myself in the leaves of Eucalyptus species, particularly in those of the "Red Stringybark" *Eucalyptus macrorhyncha*, it was shown that its formula was $C_{27}H_{28}O_{16}$, that it was a quercetin glucoside, and that on hydrolysis it formed quercetin and a glucose.

There were at that time two other quercetin glucosides closely resembling myrticolorin; one, *Osyritrin*, discovered by Mr. A. G. Perkin, and obtained from the Cape Sumach *Colpoon compressum;* the other known as *Violaquercitrin*, described by Mandelin[3] and obtained from the flowers of *Viola tricolor variensis.* These three glucosides were supposed to differ from each other by one molecule of water of hydrolysis only.

Further researches on these three glucosides have recently been undertaken by Mr. Perkin, and in a note on *Violaquercitrin* he shows that the formula for this substance was incorrectly stated by Mandelin, and that its formula is $C_{27}H_{28}O_{16}$. It is thus identical with *Myrticolorin.*

[1] Trans. Chem. Soc., 1898, p. 697. [2] *Loc. cit.,* 1897, p. 1132.
[3] Jahresber., 1883, p. 1369. [4] Proc. Chem. Soc., XVII., p. 88.

Continuing the investigation upon his own *Osyritrin* he found that this substance also has the same formula, and that it is identical with *Myrticolorin* and with *Violaquercitrin.*[1] These three glucosides are thus identical substances, although obtained from three different natural orders; they all have the formula $C_{27}H_{28}O_{16}$ and all give identical substances chemically.

In the original paper it was shown that the osazone formed with the sugar of myrticolorin melted at 190° C., thus suggesting galactose, but from subsequent investigations I find that this sugar is not present and evidently the osazone was not pure, as later determinations on several different portions of material gave identical osazones melting at 204 — 205° C., so that the osazone formed with the sugar of myrticolorin is glucosazone. The same melting point is obtained with the osazones from the sugars of both osyritrin and violaquercitrin.

The glucoside, myrticolorin, undergoes the following reaction when decomposed with acid, quercetin and glucose being formed:—

$$C_{27}H_{28}O_{16} + 3\ H_2O = C_{15}H_{10}O_7 + 2\ C_6H_{12}O_6.$$

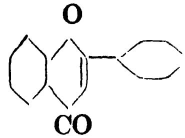
Quercetin is a member of the flavone group and contains five hydroxyls, two of which are in the ortho position relatively to each other. It appears probable that the location of the hydroxyls in the molecule of the several members of this group decides the tinctorial peculiarities of these bodies, although it does not appear necessary for the hydroxyls in the several members of the flavone series to take up the ortho position to form true dyestuffs.

In the members of the anthraquinone series (alizarin or dihydroxyanthraquinone for instance) the two hydroxyls are in the ortho position relatively to each other, and it is

[1] Trans. Chem. Soc., 1902, p. 477.

generally accepted that this position is necessary for the hydroxyl radicles in the anthraquinone dyestuffs.

The general structural formula for the members of the quercetin or phenylated pheno-γ-pyrone group is



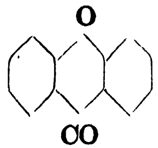
the number and position of the hydroxyls in the molecule characterising the several members of this group. The following list includes most of the natural yellow dyestuffs belonging to this group, the constitution of which are known, and in which the hydroxyl radicles are intact:—

Myricetin, from the bark of *Myrica nagi*, with 6 hydroxyls.
Quercetin, (from various sources), with 5 hydroxyls.
Morin, from Old Fustic, *Morus tinctoria*, with 5 hydroxyls.
Fisetin, from *Rhus continus* and *R. rhodanthema*, with 4 hydroxyls.
Luteolin, from Weld, *Reseda luteola*, with 4 hydroxyls.
Kampherol, from galanga root, *Alpinia officinarum*, with 4 hydroxyls.
Apigenin, from parsley, *Apium petroselinum*, with 3 hydroxyls.
Galangin, from galanga root, with 3 hydroxyls.
Chrysin, from poplar buds, with two hydroxyls.

All these contain 15 carbon atoms in the molecule.

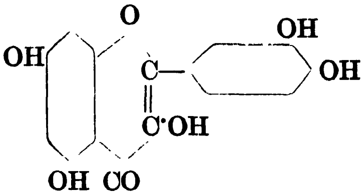
Other members of this series are known which exist naturally as methyl ethers. Rhamnetin, from Persian berries, is the monomethyl ether of quercetin, and is a typical example of the members belonging to this subclass.

All natural colouring matters, however, do not belong to the quercetin group, some being known that are derivatives of the dipheno-γ-pyrone or xanthone group



A typical example of this class is gentisin, the dye material of gentian root *(Gentiana lutea)*, and which has the constitution of a dihydroxy monomethyl ether.

The constitutional formula for quercetin—first suggested by Herzig—is as follows:—



and this on heating in concentrated potash at 180—200°C. for half an hour, breaks up into protocatechuic acid and phloroglucinol. This method of decomposition has been found most useful in determining the structure of the several members of the quercetin group, and the position of the hydroxyl radicles. It has been the information gained in this way that has enabled the hydroxyls in morin to be located. This substance is isomeric with quercetin, the only difference being that the nucleus in morin is resocinol instead of catechol as in quercetin, so that these two hydroxyls in morin are in the meta position, whereas they take up the ortho position in quercetin.

It has been suggested[1] that the tinctorial property of quercetin is due to the two distinct pairs of hydroxyl groups in its molecule, but morin also dyes very well and is largely used commercially as a dyestuff; both molecules contain one hydroxyl in the pyrone ring.

[1] Perkin and Martin—Trans. Chem. Soc., 1897, p. 821.

From much recent work in this direction it appears probable, that the tinctorial influence exercised by the location in the molecule of certain radicles in these natural yellow dyeing materials, will eventually be completely understood.

Air dried myrticolorin contains 3 molecules of water of crystallisation, and this is not entirely removed until several degrees above 130° C. It also forms a monopotassium derivative $C_{27}H_{27}O_{16}K$ when treated with potassium acetate.[1] It also reacts with sulphuric acid, when this is added to a solution in boiling acetic acid, forming salts of quercetin containing one molecule of acid $C_{15}H_{10}O_7$, H_2SO_4. When myrticolorin is decomposed by boiling three hours with dilute sulphuric acid, and allowed to stand about 20 hours, almost the theoretical amount of quercetin (49·67 per cent.) is obtained.

The value of quercetin glucosides for dyeing purposes is well known, and the amount of myrticolorin obtained from the leaves of *E. macrorhyncha* is somewhat large, as $8\frac{1}{2}\%$ of dried myrticolorin was obtained commercially from the dry ground leaves.[2] The extraction of the dye material is exceedingly easy, so that myrticolorin may be considered to have good commercial possibilities.

I would like to express my acknowledgements to Mr. C. Still of this Museum, for much assistance in determining the commercial methods for the extraction of myrticolorin.

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[1] Perkin—Trans. Chem. Soc., 1899, p. 440.

[2] See also Journ. Roy. Soc. N.S.W., xxi., p. 377.

THE ABORIGINAL LANGUAGES OF VICTORIA.

By R. H. MATHEWS, L.S.,

Memb. Assoc. Étran. Soc. d'Anthrop. de Paris.

[*Read before the Royal Society of N. S. Wales, July 2, 1902.*]

SYNOPSIS.—Introductory. Orthography. The Tyattyalla Language. The Tyâpwurru and Wuddyâwurru Dialects. The Thâguwurru Language. The Woiwurru Dialect. The Brabirrawulung Language. Vocabularies of Tyattyalla and Brabirrawulung Words.

In 1898 I contributed to the Anthropological Society at Washington an article describing the initiatory rites and social organisation of the native tribes of Victoria.[1] On that occasion I stated: "The only way at the present time to accomplish what I have indicated [to define the boundaries of the nations into which the aborigines were divided] is to study the languages or dialects of the population, grouping together those which have an evident affinity." It is now my intention to proceed with the work I commenced in 1898.

At the time of writing the article referred to I had personally studied only two of the native tongues, but since then I have made several additional journeys through Victoria at various times for the purpose of visiting the remnants of the different tribes and further examining the structure of their speech. As no previous author has attempted to supply the elements of the grammar of the languages of the native tribes of Victoria, the pleasing duty has devolved upon me to present to the reader a portion of my researches in this direction. Gathering this information from the lips of the natives, and reducing it to

[1] "The Victorian Aborigines: their Initiation Ceremonies and Divisional Systems."—American Anthropologist, Vol. xi., pp. 325–343, with map of Victoria, plate v.

a written form, has been a tedious and laborious task, the difficult and tangled nature of which can be grasped only by those who have embarked on the same line of investigation. Space will preclude the consideration in this article of more than the leading outlines of the constitution of the several tongues.

In all the languages of Victoria, in every part of speech which is subject to inflection, there is a double form of the first person of the dual and plural—one of which includes, and the other excludes, the individual addressed. Mr. J. Dawson[1] observed two forms of the dual: "We two, thou and I; we two, he and I;" but as he does not refer to this peculiarity in the first person of the plural, I may be pardoned for claiming its discovery in Victoria, having also previously reported its existence in the languages of New South Wales.[2]

In all the dialects having the Tyattyalla structure, there are four numbers—singular, dual, triple and plural. The triple or trial number has also two forms in the first person —one to include the person spoken to, and the other to exclude him. The triple number has also been found by me in the Thaguwurru and Woiwurru tongues, in which it is now reported for the first time. In the eastern portion of the Thaguwurru country, the triple is seldom used—the speech of the people having coalesced with that of their neighbours on the east, among whom the dual only is recognised.

Among the native tribes of Victoria dealt with in this paper, inflection for person and number is not confined to the verbs and pronouns, but extends to many of the nouns, prepositions, adverbs and interjections, a peculiarity which

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[1] Australian Aborigines of Western Districts of Victoria, (1881) p. 49.

[2] "The Thurrawal, Gundungurra and Dharruk Languages,"—Journ. Roy. Soc. N.S.W., Vol. xxxv., pp. 127–160.

was reported by me in certain aboriginal languages of New South Wales last year.[1]

It is beyond the scope of a short article like this to furnish vocabularies of the dialects of every tribe. I have therefore given two vocabularies only—the Tyattyalla and the Brabirrawulung—the former being representive of the tongues of Western Victoria, and the latter of Eastern Victoria.

It may be added that a few of Mr. R. B. Smyth's correspondents noticed a dual in the pronouns, but the existence of an inclusive and exclusive form in the dual and plural was not observed by them. Portions of the conjugations of a few verbs were also supplied to Mr. Smyth by some of his contributors, but the grammatical structure of the dialects was left untouched.

Applying a possessive suffix to nouns has been observed in several islands of Polynesia. It was also briefly noticed in a few Victorian tribes by some of Mr. R. B. Smyth's correspondents. The distinction between the "we inclusive" and "we exclusive" has been noticed in many dialects of Polynesia and elsewhere, although not to such a full extent as exemplified in the following pages.

The existence of a trial number was reported years ago in Aneityum[2] and some other islands of the Pacific Ocean, and was observed to some extent in the pronouns of the Woddowro tribe in Victoria by Mr. Francis Tuckfield.[3]

The *trial* number, as existing in the native languages of Victoria, is different in character from that observed in some other countries. For example, in the New Hebrides the case-endings of the dual, trial, and plural are independent, and vary from each other in form, thus:

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[1] *Op. cit.*, p. 127.

[2] Rep. Aust. Assoc. Adv. Sci., I., pp. 482 - 483. [3] *Op. cit.*, VII., p. 482.

We (dual inclusive) Akaijan
We (trial inclusive) Akataij
We (plural inclusive) Akaiji

But among the Victorian tribes, the trial number is formed by adding another case-ending to that of the plural. For example, in the Tyattyalla, Tyâpwurru and Wuddyâwurru languages, an additional ending, *kullik*, is tacked on to the suffix of the plural, as follows:

We (plural inclusive) Yurwengurruk
We (trial inclusive) Yurwengurrukkullik.

In the Thaguwurru and kindred tongues, the word *baiap* is substituted for *kullik*, but it is employed in precisely the same manner—It is added to the suffix of the plural—as in the following example:

We (plural inclusive) Wanganyin
We (trial inclusive) Wanganyinbaiap.

In the Motu, one of the languages of New Guinea, Rev. W. G. Lawes reports that the dual and trial of pronouns are formed by additions to the plural.[1]

The following authors have published vocabularies of some of the dialects of Victoria:—

Mr. R. B. Smyth, "The Aborigines of Victoria," Vol. II., pp. 1 — 220.

Mr. E. M. Curr, "The Australian Race," Vol. III., pp. 437 — 589.

Mr. J. Dawson, "The Australian Aborigines of the Western Districts of Victoria," pp. 1 — 84.

Mr. J. J. Carey, from the manuscript of Mr. F. Tuckfield, "Report Austr. Assoc. Adv. Science," Vol. VII., pp. 840 — 872.

There are other vocabularies, but the foregoing will be sufficient for ordinary purposes of reference.

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[1] Motu Grammar and Vocabulary, p. 9.

All the languages of eastern Victoria, although differing widely in vocabulary from the Thurrawal,[1] reported by me last year, are yet substantially the same in grammatical structure as that language. This remark also applies to that portion of Victoria situated west of the 145th meridian of longitude, the only difference being that the western districts have the trial number, whilst the eastern have not. The eastern and western tongues both have inflexion for number and person of nouns, adverbs, prepositions, etc., in addition to that of the verbs and pronouns; both have the double form of the first person in all numbers beyond the singular. In the vocabularies of all these languages—the Thurrawal, Tyattyalla, Brabirrawulung, etc.—there are several words in common, showing a community of origin.[2]

Some of Mr. R. B. Smyth's correspondents ventured to send him stories purporting to be told in certain native dialects.[3] I have looked over all these stories, and can pronounce them to be mere ungrammatical jargon, written by men who knew nothing of the structure of the languages they were dealing with. They are on a par with the pigeon-English of the Chinese costerer: "Plenty me got him cabbagee."

It is desired in this place to thank all those gentlemen who are in charge of Aboriginal Stations in Victoria, for allowing me free access to the natives under their control, and for other acts of kindness during my visits to their respective districts, whilst I was engaged in linguistic and other investigations among the native tribes of Victoria.

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[1] Journ. Roy. Soc. N S.W., Vol. xxxv., pp. 127 - 160.

[2] "The Origin, Organisation and Ceremonies of the Australian Aborigines,"—Proc. Amer. Philos. Soc., Phila., Vol. xxxix., pp. 556 - 578, with map of Australia, plate viii.

[3] "Aborigines of Victoria," Vol. ii., pp. 48, 49, and pp. 53, 54.

Orthography.

Eighteen letters of the English alphabet are sounded, comprising thirteen consonants—*b*, *d*, *g*, *h*, *k*, *l*, *m*, *n*, *p*, *r*, *t*, *w*, *y*—and five vowels—*a*, *e*, *i*, *o*, *u*.

The system of orthoepy adopted is that recommended by the circular issued by the Royal Geographical Society, London, with the following qualifications:—

It is frequently difficult to distinguish between the short sound of *a* and *u*. A thick sound of *i* is occasionally met with, which closely resembles the short sound of *u* or *a*.

As far as possible, vowels are unmarked, but in some instances the long sound of *a*, *e*, and *u* are indicated thus, â, ê, û. In a few cases the short sound of *u* has been marked thus, ŭ.

G is hard in all cases. *R* has a rough, trilled sound, as in hurrah! *W* always commences a syllable or word.

Ng at the beginning of a word or syllable as *ngu* in *ngu-ya*, a camp, has a peculiar sound, which can be got very closely by putting *u* before it, as *ungu'*, and then articulating it as one syllable. At the end of a syllable it has substantially the sound of *ng* in "sing."

The sound of the Spanish ñ is frequent; at the beginning of a word or syllable I have given it as *ny*, but when terminating a word the Spanish letter is used. *Y* at the beginning of a word or syllable has its ordinary consonant value.

Dh is pronounced nearly as *th* in "that," with a slight sound of *d* preceding it. *Nh* has also nearly the sound of *th* in "that," but with an initial sound of the *n*. A final *h* is guttural, resembling *ch* in the German word joch.

T is interchangeable with *d*, *p* with *b*, and *g* with *k*, in most words where these letters are employed. *Ty* and *dy* at the commencement of a word or syllable have nearly

the sound of *j* or *ch*, thus *dya* or *tya* closely resemble *ja* or *cha*. At the end of a word or syllable, *ty* or *dy* is sounded as one letter; thus, *lity*, a child, can be pronounced exactly by assuming *e* to be added to the *y*, making it lit-ye; then commence articulating the word, including the *y*, but stopping short without sounding the added *e*. *Dy* at the end of a word can be pronounced in the same way, the sound of *d* being substituted for that of *t*. In all cases where there is a double consonant, each letter is distinctly enunciated.

THE TYATTYALLA LANGUAGE.

The Tyat′-tyal-la is spoken by the natives about Lakes Werringen and Albacutya, and is representative of the speech of all the tribes scattered over the whole of that moiety of Victoria situated west of a line from the sea coast at Geelong[1] through Bendigo northerly to Pyramid Hill, with the exception of the frontage to the Murray River, from the latter place downwards.

The Boandik language,[2] spoken in the south-east corner of South Australia, defined by being situated to the south of a line from Kingston to Border Town, is the same in grammatical structure as the languages of western Victoria herein dealt with.

NOUNS.

Number.—There are four numbers—singular, dual, trial and plural. Wutyu, a man; wutyu-buliñ, a couple of men; wutyu-kullik, three men; wutyu-getyaul, several men.

Gender.—Wutyu, a man. Laiaruk, a woman. Kulkun, a boy. Lanangurk, a girl. Among animals, mamuk is used for "male," and pabuk for "female," both in mammals and birds; thus, wille mamuk, a buck opossum; kauar

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[1] "Victorian Aborigines etc.,"—American Anthropologist, XI, pp. 331 - 336. Map.

[2] *Op. cit.*, pp. 331 - 336, and map of Victoria.

mamuk, a cock emu; wille pabuk, a female opossum. The kangaroo, mindyun, has an independent name, dhallung, for the buck, and another, muty, for the doe. This rule also applies to some other animals.

Case.—The principal cases are the nominative, possessive, accusative, instrumental, dative and ablative.

There are two forms of the nominative, one of which merely names the object under attention, as gal, a dog, and then the noun remains unchanged. But when a transitive verb is used, the noun takes a suffix, as, Wutyuku mindyul buyin, a man a kangaroo killed. Kulkunu bandyal kargin, a boy a codfish caught. Gallu wille bundin, a dog an opossum bit.

Possessive—A suffix is applied to the possessor and also to the thing possessed, as Wutyuga gattimgattimuk, a man's boomerang. Laiura berkanuk, a woman's yamstick. Kulkuna lahrnuk, a boy's camp. The grammar also admits of putting the thing possessed foremost in the sentence in certain instances, for the sake of euphony, and then the suffixes are transposed, as, lahrnga laiuk, instead of laiura lahrnuk, a woman's camp.

Anything over which possession can be exercised is subject to inflection for number and person. In the first person of the dual, trial and plural, there are two forms of the word—one, marked "incl.," including the person spoken to; and the other, marked "excl.," in which the person addressed is excluded:

Person.		Singular.
1st	My boomerang,	Gattimgattimek
2nd	Thy boomerang,	Gattimgattimin
3rd	His boomerang,	Gattimgattimuk

Person.		Dual.
1st	Our, incl., boomerang,	Gattimgattimŭl
	Our, excl., boomerang,	Gattimgattimullŭk

Person.	Trial.
1st	Our, incl., boomerang, Gattimgattimurrakullik
	Our, excl., boomerang, Gattimgattimandakullik

Person	Plural.
1st	Our, incl., boomerang, Gattimgattimurrak
	Our, excl., boomerang, Gattimgattimandak

The second and third persons of the dual, trial and plural are omitted for want of space.

Accusative.—The accusative is the same as the simple nominative. Instrumental.—Where a weapon or other article is the remote object, the instrumental case takes the agent suffix, as, Wutyu gattimgattimu burdenan, a man with a boomerang struck I. Dative.—Lahrndal, to a camp. Ablative.—Lahrnung, from a camp.

ADJECTIVES.

Adjectives are inflected for number and case and follow the nouns they qualify, as under:

Nominative—Wutyu kurunge, a man large.

Nom. agent—Wutyuk kurunguk gattimgattim yunggin, a man large a boomerang threw.

Possessive—Wutyuga kurunga gattimgattimuk, a large man's boomerang.

Dative—Wutyugal kurungal, to the big man.

Ablative—Wutyugung kurungung, from the big man.

Comparison is effected by such expressions as "This is good; that is bad; this is very good," and so on, similarly to the Thurrawal and Gundungurra languages.[1]

PRONOUNS.

Pronouns are inflected for number and case, and are without gender. There are two forms of the third person in the dual, trial and plural, one of which includes the individual addressed, and the other excludes him. The

[1] Journn. Roy. Soc. N.S.W., xxxv., pp. 133 – 137, 150, 152.

following are examples in the nominative and possessive cases:

Singular.

1st Person	I,	Yurwek	Mine,	Yurwangek
2nd „	Thou,	Yurwin	Thine,	Yurwangin
3rd „	He,	Yuruk	His,	Yurwanguk

Dual.

Person.				
1st	We, incl.,	Yurwal	Ours, incl.,	Yurwangal
1st	We, excl.,	Yurwalluk	Ours, excl.,	Yurwangalluk
2nd	You,	Yurwula	Yours,	Yurwangwula
3rd	They,	Yurbullang	Theirs,	Yurwangbullang

Trial.

1st Person	We, incl.,	Yurwengurrakullik
1st Person	We, excl.,	Yurwendakullik
2nd „	You,	Yurwuddakullik
3rd „	They,	Yurwennakullik
1st Person	Ours, incl.,	Yurwangengurrakullik
1st Person	Ours, excl.,	Yurwangendakullik
2nd „	Yours,	Yurwanguddakullik
3rd „	Theirs,	Yurwangennakullik

Plural.

Person.				
1	We, incl.,	Yurwengurrak	Ours, incl.,	Yurwangengurrak
1	We, excl.,	Yurwendak	Ours, excl.,	Yurwangendak
2	You,	Yurwuddak	Yours,	Yurwanguddak
3	They,	Yurwennak	Theirs,	Yurwangennak

The objective pronouns are as under:

Singular	1st Person	Me,	Nyungek
	2nd „	Thee,	Nyungin
	3rd „	Him,	Nyunguk
Dual	1st Person	Us, incl.,	Nyungal
	1st Person	Us, excl.,	Nyungalluk
	2nd „	You,	Nyuwolak
	3rd „	Them,	Nyuwolang
Trial	1st Person	Us, incl.,	Nyungingurrakullik
	1st Person	Us, excl.,	Nyungandakullik
	2nd „	You,	Nyunguddakullik
	3rd „	Them,	Nyungannakullik
Plural	1st Person	Us, incl.,	Nyungingurrak
	1st Person	Us, excl.,	Nyungandak
	2nd „	You,	Nyunguddak
	3rd „	Them,	Nyungannak

These full forms of the pronouns are used chiefly in answer to a question; for example, "who is there?" could be replied to, "yurwalluk" (we, dual exclusive). "Whose boomerang is this?" might elicit the answer, "yurwangek" (mine), and so on. In conversation the pronominal suffixes are used with the verbs, nouns, or other parts of speech, as shown in the text of this paper.

The following are a few examples of the interrogatives: Who is there, winya nyua? Whom for, winyerra? Whom from, winyung? What, nyanyo? What for, nyanguk?

Demonstratives are numerous, and usually follow the word qualified. They vary with the position of the object referred to with regard to the speaker, and also with its distance from him, and are often inflected for number and person. Ging, this; ginyu, that.

VERBS.

Verbs have the same numbers and persons as the pronouns, three tenses and three moods. The verb "to be" has a substitute in the word yuma, which is inflected for person and number. If an adjective, adverb, or other suitable word be taken as a predicate, we get the following illustration:

1st Person	Good am I,	Dhalguk yuman
2nd ,,	Good art thou,	Dhalguk yumar
3rd ,,	Good is he,	Dhalguk yuma

and so on through all the persons and numbers. Or the inflection can be put on the predicate, as follows:

1st Person	Here I am,	Gimban yuma
2nd ,,	Here thou art,	Gimbar yuma
3rd ,,	Here he is,	Gimba yuma

The following is the conjugation of the principal elements of the verb taka, "to beat." The present tense is given in full, but it is thought the first persons of the remaining tenses will be sufficient.

Active Voice—Indicative Mood.

Present Tense.

Singular	1st Person	I beat	Takan
	2nd ,,	Thou beatest	Takar
	3rd ,,	He beats	Taka

Dual	1st Person	We, incl., beat,	Takangul
		We, excl., beat,	Takangulang
	2nd ,,	You beat,	Takawul
	3rd ,,	They beat,	Takabullang

Trial[1]	1st Person	We, incl., beat,	Takangukullik
		We, excl., beat,	Takandakullik
	2nd ,,	You beat,	Takawakullik
	3rd ,,	They beat,	Takanakullik

Plural	1st Person	We, incl., beat,	Takangu
		We, excl., beat,	Takandang
	2nd ,,	You beat,	Takawat
	3rd ,,	They beat,	Takanaty

Past Tense.

Singular	1st Person	I beat,	Takinan
	2nd ,,	Thou beatedst,	Takinar
	3rd ,,	He beat,	Takin

Future Tense.

Singular	1st Person	I will beat,	Takinyan
	2nd ,,	Thou wilt beat,	Takinyar
	3rd ,,	He will beat,	Takiñ

Imperative Mood.

Singular 2nd Person	Beat,	Takak
Dual	Beat,	Takakul
Trial	Beat,	Takakatkullik
Plural	Beat,	Takakaty

The negative form is, Bowan takak, beat not.

Conditional Mood.

Perhaps I will beat, Takinyan mumba, and so on.

[1] This is the first time the trial, or triple, number has been reported in the verbs of any Victorian tribe.

Middle Voice—Indicative Mood.

Present Tense.

Singular	1st Person	I beat myself,	Takalangan
	2nd „	Thou beatest thyself,	Takalangar
	3rd „	He beats himself,	Takalang

The inflexion can be continued through all the numbers, persons, tenses and moods.

Reciprocal.

Present Tense.

Dual	We, incl., beat each other,	Takdyerrangungal
Trial	„ „	Takdyerrangangukullik
Plural	„ „	Takdyerrangangu
Dual	They beat each other,	Takdyerrangbulang
Trial	„ „	Takdyerrangakullik
Plural	„ „	Takdyerrangaty

The inflexion applies to the second person of the dual, trial and plural, and also to the exclusive form of the first person.

Adverbs.

Yes, ngaie. No, wrekkea. Yesterday, dyalligea. To-morrow, bêrbo. By and bye, mulluk nyungga. Long ago, mullamea. In the future, mullûkmea. Here, gimba. There nyua. There (farther), mainyuk. There (farther still), maiyo. Where is the camp, windyalahr? Where art thou from, windyangat kurtung? Whither goest thou, winyangingukka? How many, nyappur?

Some adverbs are capable of inflection for person and number, as follows:

Singular	Where art thou?	Windyar
Dual	Where are you?	Windyawul
Trial	Where are you?	Windyatkullik
Plural	Where are you?	Windyaty

All the persons in each number can be inflected.

Prepositions.

The comprehensive inflections in every part of speech tend to diminish the use of prepositions, which are not numerous. Several prepositions admit of inflection, as in the following example.

Singular	1st Person	Behind me,	Walmengek
	2nd ,,	Behind thee,	Walmengin
	3rd ,,	Behind him,	Waimenguk
Dual 1st Person		Behind us, incl.,	Walmengul
		Behind us, excl.,	Walmengulluk
Trial 1st Person		Behind us, incl.,	Walmengangurrakullik
		Behind us, excl.,	Walmengandakullik
Plural 1st Person		Behind us, incl.,	Walmengangurrak
		Behind us, excl.,	Walmengandak

The other persons are omitted to save space.

Conjunctions.

A short word ba, or its euphonic variants, bam, ma, etc., appears to serve the purpose of "or," "and," or "because," according to the context.

Interjections and Exclamations.

These are not numerous. Halt thou, tyarrigi! Halt you (dual), tyarrigiwal! Halt you (trial), tyarriyuatkullik! Halt you (plural), tyarriyuat! Take care, ngatwurri! Cease, kurungai! Exclamation of surprise, yukkai!

Numerals.

One, kaiŭp. Two, bulaty.

Tyapwurru and Wuddyawurru Dialects.

When travelling on the Hopkins River a few years ago, I met a couple of old aborigines, one of whom was a native of that river, and spoke Tyâpwurru, whilst the other man hailed from Ballarat district, and spoke Wuddyâwurru. On my taking a considerable number of notes of their dialects,

I found that the grammatical structure of both was identical, although differing somewhat in vocabulary. My Wuddyâwurru informant, "Jack Phillips," died in 1901. As both dialects are the same in structure as the Tyattyalla tongue herein described, I shall introduce the pronouns only in this paper. The following are the nominative and possessive forms:

Singular.

1st Person	I,	Bangek	Mine,	Bangordigek
2nd ,,	Thou,	Bangin	Thine,	Bangordigin
3rd ,,	He,	Banguk	His,	Bangordiguk

Dual.

Person				
1st	We, incl.,	Bangal	Ours, incl.,	Bangordingal
	We, excl.,	Bangalluk	Ours, excl.,	Bangordingalluk
2nd	You,	Bangbula	Yours,	Bangordiwula
3rd	They,	Bangbullang	Theirs,	Bangordibullang

Trial.

1st Person	We, incl.,	Bangadukullik
	We, excl.,	Bangwudyakullik
2nd ,,	You,	Bangutkullik
3rd ,,	They,	Banganakullik

1st Person	Ours, incl.,	Bangordingadukullik
	Ours, excl.,	Bangordiwŭdyakullik
2nd ,,	Yours,	Bangordingûtkullik
3rd ,,	Theirs,	Bangordiyanakullik

Plural.

Person				
1st	We, incl.,	Bangaduk	Ours, incl.,	Bangordingaduk
	We, excl.,	Bangwŭdyak	Ours, excl.,	Bangordiwŭdyak
2nd	You,	Bangût	Yours,	Bangordingût
3rd	They,	Banganak	Theirs,	Bangordiyanak

Mr. J. J. Carey, from the MS. of Mr. F. Tuckfield, published an incomplete list of pronouns[1] closely resembling the nominative case of the foregoing, but differing considerably from the possessive. As Mr. Tuckfield makes no mention of the double form in the first person of the dual,

[1] Rep. Austr. Assoc. Adv. Sci., Vol. vii., p. 853.

trial and plural, we may safely infer that he did not observe it. The verbs of these languages are inflected for singular, dual, trial and plural, the same as the pronouns. Nouns, adjectives, prepositions, etc., are also declined for number and person, as in the Tyattyalla language.

The Thaguwurru Language.

The Thâguwurru and kindred tribes occupied the country drained by the Goulburn, Campaspe, and Ovens rivers,[1] exclusive of a strip along the valley of the Murray, and were bounded on the south by the main dividing range. For the grammar of the languages of the Murray River tribes, the reader is invited to peruse other articles written by me on this subject.

Nouns.

Number.—Nouns have four numbers, as in the Tyattyalla. Marŭm, a kangaroo. Marŭm-bulaiñ, a pair of kangaroos. Murŭm-baip, three kangaroos. Marŭm-buladhuin, several kangaroos.

Gender.—Kulin, a man. Bedyur, a woman. Yernyern, a youth. Burnai, a girl. Bubup, a child of either sex. In animals the female is denoted by babannu, and the male by laigurn; thus, burraimul babannu, an emu hen; burraimul laigurn, a cock emu; marŭm laigurn, a buck kangaroo Bûnyer means a doe of any animal when enceinte.

Case.—The nominative-simple indicates any object at rest, as wangim, a boomerang; yirrangin, a dog. Gannañ, a yamstick. Kargin, a tomahawk. The nominative-agent represents the subject in action, as, Kulindya walert tyilbai, a man an opossum struck. Yirrangina marŭm bûndai, a dog a kangaroo bit. Bedyura yôk bangai, a woman an eel

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[1] "The Victorian Aborigines, etc."—American Anthropologist, XI., pp. 326 - 330, with map of Victoria.

caught. Babannunnu bubup tyilbai, the mother the child beat.

Possessive.—The proprietor and the property each take a suffix, as, Kulindyal wangimu, a man's boomerang. Bedyural gannanyu, a woman's yamstick.

The article possessed can be inflected for person and number, as in the Tyattyalla.

Singular	1st Person	My boomerang,	Wangimik
	2nd ,,	Thy boomerang,	Wangimin
	3rd ,,	His boomerang,	Wangimo

Dual	1st Person	Our, incl., boomerang,	Wangimngal
		Our, excl., boomerang,	Wangimngun
	2nd ,,	Your boomerang,	Wangimbul
	3rd ,,	Their boomerang,	Wangimballain

Trial.

Person.		
1st	Our, incl., boomerang,	Wangimngunyinbaiap
	Our, excl., boomerang,	Wangimngunyinubaiap
2nd	Your boomerang,	Wangimngutbaiap
3rd	Their boomerang.	Wangimdhanbaiap

Plural.

1st Person	Our, incl., boomerang,	Wangimngunyin
	Our, excl., boomerang,	Wangimngunyinu
2nd ,,	Your boomerang,	Wangimngut
3rd ,,	Their boomerang,	Wangimdhan

Accusative.—This is the same as the nominative-simple.

Instrumental.—When an instrument is the remote object of the verb, a suffix is applied to it, as, Waiadhan mŭnyi wangimdya, struck I him with a boomerang.

Dative.—Yilamdha, to a camp. Ablative.—Yilamu, from a camp.

Adjectives.

Adjectives are inflected for number and case like the nouns. Kulin dhangula, a man large. Kulindya dhangula marŭm tyilbai, a big man struck a kangaroo. Kulindyal dhangulal yirranginu, a big man's dog.

PRONOUNS.

The nominative and possessive pronouns are as follows:

Singular.

1st Person	I,	Wan	Mine,	Nugalik
2nd ,,	Thou,	War	Thine,	Nugalin
3rd ,,	He,	Munyi	His,	Nugalo

Dual.

1st Person	We, incl.,	Wangŭl	Ours, incl.,	Nugalngul
	We, excl.,	Wangŭn	Ours, excl.,	Nugalngun
2nd ,,	You,	Wabûl	Yours,	Nugalbul
3rd ,,	They,	Munyibulabil	Theirs,	Nugalobullain

Trial.

1st Person	We, incl.,	Wanganyinbaiap
	We, excl.,	Wanganyinyubaiap
2nd ,,	You,	Watgurabilbaiap
3rd ,,	They,	Munyigadhanbaiap

1st Person	Ours, incl.,	Nugalnganyinbaiap
	Ours, excl.,	Nugalnganyinyubaiap
2nd ,,	Yours,	Nugalngûtbaiap
3rd ,,	Theirs,	Nugalodhan

Plural.

Person.				
1st	We, incl.,	Wanganyin	Ours, incl.,	Nugalnganyin
	We, excl.,	Wanganyinyu	Ours, excl.,	Nugalnganyinyu
2nd	You,	Watgurabil	Yours,	Nugalngût
3rd	They,	Munyigadhan	Theirs,	Nugalodhan

Interrogatives—Ngunying, what? Yinarôp, who? These are declinable for number. Demonstratives—Munyi, this; male, that.

VERBS.

Gurin appears to be an equivalent of the verb "to be":

1st Person	Good am I,	Bûrndap gurinan
2nd ,,	Good art thou,	Bûrndap guriner
3rd ,,	Good is he,	Bûrndap gurin

The fundamental parts of the verb tyilba, to beat, are represented in this conjugation:—

Active Voice.

Indicative Mood—Present Tense.

Singular	1st Person	I beat,	Tyilbuinan
	2nd „	Thou beatest,	Tyilbuiner
	3rd „	He beats,	Tyilbuin
Dual	1st Person	We, incl., beat,	Tyilbuingul
		We, excl., beat,	Tyilbuingun
	2nd „	You beat,	Tyilbuinbul
	3rd „	They beat,	Tyilbuinbulláin
Trial	1st Person	We, incl., beat,	Tyilbuingunyinbaiap
		We, excl., beat,	Tyilbuingunninyubaiap
	2nd „	You beat,	Tyilbuinatbaiap
	3rd „	They beat,	Tyilbuinurbaiap
Plural	1st Person	We, incl., beat,	Tyilbuingunyin
		We, excl., beat,	Tyilbuingunninyu
	2nd „	You beat,	Tyilbuinat
	3rd „	They beat,	Tyilbuinur

Past Tense.

Singular	1st Person	I beat,	Tyilbuddhan
	2nd „	Thou beatedst,	Tyilbuddhar
	3rd „	He beat,	Tyilbai

Future Tense.

Singular	1st Person	I will beat,	Tyilbunnhan
	2nd „	Thou wilt beat,	Tyilbunnher
	3rd „	He will beat.	Tyilbuñ

Imperative Mood.

Singular—Beat, Tyilbak. Trial—Beat, Tyilbagubaiap

Dual—Beat, Tyilbakwula. Plural—Beat, Tyilbagu

The negatives are Ngabŭk tyilbak. Ngabŭkwula tyilbak. Ngabugabaiap tyilbak. Ngabuga tyilbak.

Conditional Mood.

Singular—Perhaps I will beat,	Gullai tyilbunnha
Dual—Perhaps we, incl., will beat,	Gullai tyilbunnhungal
Trial—Perhaps „	Gullai tyilbunnunginyinbaiap
Plural—Perhaps „	Gullai tyilbunnunginyin

Middle Voice—Indicative Mood—Present Tense.

Singular	1st Person	I beat myself,	Tyilbarballinan
	2nd ,,	Thou beatest thyself,	Tyilbarballinher
	3rd ,,	He beats himself,	Tyilbarballiñ

All the numbers, persons, tenses, and moods can be conjugated, as in the active voice.

Reciprocal.

Dual—We, incl.,	beat each other,		Tyilpdyiringal
Trial—	,,	,,	Tyilpdyirinaibaip
Plural—	,,	,,	Tyilpdyirinai

Adverbs.

Yes, ngaii. No, dhâ-ung and dhândyak. Nothing, dhagumbert. Now, dyumi. Karremiñ, to-day. Yerambui, to-morrow. Yulungui, yesterday. Bambôgadhak, long ago. Here, mŭgulli. There, mangi. Indharu gurinher, where art thou? Indhagurin yilam, where is the camp? Indhar gurnange, which way (or where) wentest thou? Ngunungo, whence?

Prepositions.

Singular	1st Person	In front of me,	Kallinudyik
	2nd ,,	In front of thee,	Kallinudyin
	3rd ,,	In front of him,	Kallinudhu

Singular	1st Person	Behind me,	Wenyudyik
	2nd ,,	Behind thee,	Wenyudyin
	3rd ,,	Behind him,	Wenyudhu

Exclamations and Interjections.

Yukkai, surprise. Cease, themerni! Halt, yâma! Poor fellow, wurangrangga.

Numerals.

One, kôpthun. Two, bulaubil. Three, bulaubil-ba-kôp.

The Woiwurru Dialect.

This dialect was spoken on the Yarra, Saltwater, and Werribee rivers, and extended from the main dividing

range southerly to the sea-coast at Geelong, Melbourne, and Western Port. The Woiwurru tongue is the same in structure as the Thaguwurru, although some words of the vocabulary are different. About Western Port, the Woiwurru was called Būnwurru by some families, but it is essentially the same language. The rules for the declension of nouns, adjectives and other parts of speech are similar in the Thaguwurru and Woiwurru, whilst the pronouns are identical, hence my remarks will be restricted to the conjugation of a verb. In the Thaguwurru the verb "to sit" is ngurna, but in the Woiwurru it is ngulla.[1]

Indicative Mood—Present Tense.

Singular	1st Person	I sit,	Ngullabuinhan
	2nd ,,	Thou sittest,	Ngullabuinher
	3rd ,,	He sits,	Ngullabuin
Dual	1st Per.	We, incl., sit,	Ngullabuingul
		We, excl., sit,	Ngullabuingu
	2nd ,,	You sit,	Ngullabuinbul
	3rd ,,	They sit,	Ngullabuinbullain
Trial	1st Per.	We, incl., sit,	Ngullabuingunyinbaiap
		We, excl., sit,	Ngullabuingunninyubaiap
	2nd ,,	You sit,	Ngullabuinhatbaiap
	3rd ,,	They sit,	Ngullabuinhurbaiap
Plural	1st Per.	We, incl., sit,	Ngullabuingunyin
		We, excl., sit,	Ngullabuingunninyu
	2nd ,,	You sit,	Ngullabuinhat
	3rd ,,	They sit,	Ngullabuinhur

Past Tense.

Singular	1st Person	I was sitting,	Ngullabuddhan
	2nd ,,	Thou wast sitting,	Ngullabuddher
	3rd ,,	He was sitting,	Ngullambai

[1] This verb, ngulla, "to sit," is the same among the Dharruk aborigines in the district of Sydney. See my paper on "The Dharruk Language," Journ. Royal Soc., N.S.W., Vol. xxxv., pp. 155–160.

Dual	1st Per.	We, incl., were sitting,	Ngullambangul
		We, excl., were sitting,	Ngullambangun
	2nd ,,	You were sitting,	Ngullambuddhul
	3rd ,,	They were sitting,	Ngullambaibullain

Future Tense.

Singular	1st Person	I will sit,	Ngullambunnhan
	2nd ,,	Thou wilt sit,	Ngullambunnher
	3rd ,,	He will sit,	Ngullambŭn

Imperative Mood.

Singular	Sit, Ngullambi
Dual	Sit, Ngullambibul
Trial	Sit, Ngullambinâbaiap
Plural	Sit, Ngullambinat

Conditional Mood.

Singular Perhaps I will sit, Mella ngullambunnhan and so on for the remaining persons and numbers.

The negative is expressed by the word ngaiabinhu, thus, Ngaiabinhu ngullabuddhan, I sat not.

A sort of substitute for the verb "to be" is found in gaían. By taking any suitable word as a predicate we get the following:

Singular	1st Person	Here am I,	Magalu gaianik
	2nd ,,	Here art thou,	Magalu gaianin
	3rd ,,	Here is he,	Magalu gaianyo

and this can be inflected through all the persons and numbers. Another form for "I" or "I am," etc., is:

Singular	1st Person	Myself, Murrumbik
	2nd ,,	Thyself, Murrumbinher
	3rd ,,	Himself, Murrumunya

Numerals.—Kanbi, one; bendyero, two.

The Brabirrawulung Language.

The Brabirrawulung tribe occupied the territory from the Mitchell River to the Tambo, including the watersheds of these rivers and their tributaries, with the exception of

a strip of country along the sea-coast. This tribe is mentioned by R. B. Smyth in his valuable work on "The Aborigines of Victoria."

As the Brabirrawulung was formerly an important and centrally situated tribe, I propose adopting its name for the language spoken in eastern Victoria from Tarwin River to Cape Howe, and reaching back from the sea-coast northerly to the Australian Alps. In my former article on the native tribes of Victoria,[1] I adopted the name Kurnai (or Kunnai) a native word meaning "man," to distinguish all the people within the geographic limits above mentioned. I now think, however, that the term "Brabirrawulung Nation" is more appropriate, because it is the name of one of the native tribes within the region under consideration. Mr. E. M. Curr states that in his opinion, the Gippsland (Brabirrawulung) tribes are all the same stock—one descended from the other.[2] It has fallen to my lot to be the first to explain the constitution of their language. There are some differences in the vocabularies of the people occupying the eastern and western portions respectively of the area above described, but the fundamental elements of their grammar are the same throughout. The marriage laws and totemic system of the Brabirrawulung nation are the same as those in force among the adjoining coastal tribes of New South Wales, described by me in a previous communication to this Society.[3]

NOUNS.

Number.—There are three numbers—singular, dual and plural. Dyira, a kangaroo. Dyirabulung, a couple of kangaroos. Dyirawamba, several kangaroos.

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[1] "The Victorian Aborigines: their Initiation Ceremonies and Divisional Systems"—American Anthropologist, Vol. XI., pp. 330-331, and map showing distribution of the native tribes of Victoria.

[2] "The Australian Race," Vol. III., p. 540.

[3] Journ. Royal Soc. N. S. Wales, Vol. XXXIV., pp. 263, 264.

Gender.—Kunnai, a man. Rukŭt. a woman. The gender of animals is distinguished by employing the word brangula for males, and yukkana for females, as, dyira brangula, a male kangaroo; dyira yukkana, a female kangaroo.

Case.—The cases comprise the nominative, nominative-agent, possessive, accusative, dative, instrumental, and ablative.

Nominative.—Wangin, a boomerang. Kunniñ, a yamstick. Gri, a canoe. Bang and nguya, both mean a camp. Lity, a boy.

Nominative-agent.—Kunnaio waddhan dhânda, a man an opossum eats. Waddhando dyerring dhânda, an opossum leaves eats.

Possessive.—The chattel and the owner are both declined. Wanginma kunnaia, a man's boomerang. Grima rukutta, a woman's canoe. Nguyama lia, a boy's camp.

Every object over which ownership exists can be declined for person and number:

Singular	1st Person	My boomerang,	Wangingitha
	2nd ,,	Thy boomerang,	Wangingina
	3rd ,,	His boomerang,	Wanginûng

Dual 1st Per.	Our, incl., boomerang,	Wanginalla
	Our, excl., boomerang,	Wanginalanalla

and so on through all the persons and numbers.

Dative.—Banggea, to the camp. Ablative.—Bangga, from the camp.

Pronouns.

The following few examples of the nominative and possessive pronouns will exhibit their inflection:

Singular	1st Person	I,	Ngaiu	Mine,	Ngithalung
	2nd ,,	Thou,	Ngindu	Thine,	Nginnalung
	3rd ,,	He,	Nungga	His,	Nungalung

There are two pronouns for the first person of the dual, and also two for the plural, one of which is used when the person addressed is included with the speaker, and the other when the person addressed is excluded.

Interrogatives.—Nganinde, who? Ngandoanggo, who (did it). Nanma, what?

Adjectives.

Adjectives are declined for number and case, and are placed after the qualified noun.

Verbs.

Verbs have the same numbers, persons, tenses and moods as those of the Thurrawal language, reported by me last year.[1] The following are examples in the present tense of the indicative mood, of the verb "to sit," and the verb "to see":—

Singular	1st Person	I sit,	Bunnunganaty
	2nd ,,	Thou sittest,	Bunnunganin
	3rd ,,	He sits,	Bunnunganung

Singular	1st Person	I see,	Dhakanadha
	2nd ,,	Thou seest,	Dhakaninna
	3rd ,,	He sees,	Dhakanunggo

In the first person of the dual and plural, there is a variation in the suffix of the verb, indicating the inclusion or exclusion of the party spoken to.

Adverbs.

Yes, nga. No, ngalko. Tyilli, to-day. Mulgôtbilla, this evening. Yesterday, mulbôkang. Brundhu, to-morrow. Mulbitthunga, long ago. Tyillaiu, by and bye. Gunno, perhaps.

Wunman, where (singular). Wunmandu, where (dual). Wunman ngûrdŭrna, where (plural). Wulgunggo, which way? Wulngin, how?

[1] "The Thurrawal Language,"—Journ. Roy. Soc. N. S. Wales, Vol. xxxv., pp. 127 - 160.

PREPOSITIONS.

Prepositions may be either separate words, or consist of modifications of other parts of speech to give them a prepositional meaning. Several prepositions can be inflected for number and person, like the Thoorga.[1]

Bûth, between, as, Dakanbulung buth, box-trees two between (between two box-trees).

Singular	1st Person	Behind me,	Gandingitha
	2nd ,,	Behind thee,	Gandingina
	3rd ,,	Behind him,	Gandinung

NUMERALS.

Gutaban, one. Bulaman, two.

CONCLUSION.

Having now fulfilled the gratifying duty of preserving a record of the grammatical elements of the aboriginal languages of Victoria, I will ask the reader's indulgence for any shortcomings which are necessarily incident to the first attempt to master a difficult subject—especially when the immense geographic area dealt with is taken into consideration. When first entering upon this work it was found to possess no literature, beyond a few vocabularies, already referred to in the preface to this article, and all my information had to be obtained orally from the natives. Now, however, that I have overcome the initial difficulties of laying down the elements of the grammar of the several languages, it will be comparatively easy for any future investigator to extend and improve the work I have begun.

VOCABULARY.

The following vocabulary contains 325 English words, with their equivalents in Tyattyalla and also in Brabirrawulung, making a total of 650 aboriginal terms. Every word in the vocabulary has been taken down by myself in

[1] See my "Thoorga and Yookumbil Languages,"—Proc. Roy. Geog. Soc. Aust., Q. Branch, Vol. XVII., p. 49 - 73.

the camps of the natives, and much time and care have been bestowed upon the work. In the few instances where a word is given in one language, and not in the other, either the natives were not quite sure of the word, or I inadvertently omitted to note it. Again, some animals and plants are found in one district, which do not exist in another.

English.	Tyattyalla.	Brabirrawulung.
A man,	wutyu	kunnai or bra
Old man,	ngurrambuñ	burdain
Husband,	muttyumil	bulamirnda
Clever man,	bangal	dhadyan
Child,	bupup	lity
Small boy,	kulgun	
A woman,	laiuruk	rukŭt
Old woman,	ngurrumbinggurk	
Wife,	ngunnikwil	bulamirnda
Girl,	lannangurk	dallurukut
Father,	mame	munggan
Mother,	pape	yuggan

Parts of the Body.

Head,	burp	bruk
Forehead,	ginne	nirn
Hair of head,	ngurraburp	lit
Beard,	ngunye	yên
Eye,	mirr	mirri
Nose,	ka	gung
Neck,	nyanne	dhulut
Ear,	wurimbul	wring
Mouth,	tyarp	gaty
Lips,	wurra	
Teeth,	lia	ngurndak
Breast (female)	kurumbuk	bâk
Navel,	waru	mirnduk
Navelstring,		ngurrang
Afterbirth,		warndarung

English.	Tyattyalla.	Brabirrawulung.
Belly,	guna	buluñ
Heart,	wutyup	
Back,	wârem	ngurruk
Tongue,	tyalin	tyillain
Liver,	boty	walaualak
Arm,	thatyuk	birndang
Shoulder,	burpurung	dâng
Elbow,	nguyuk	dyallung
Hand,	munya	brety
Thigh,	mulul	dyurrañ
Knee,	putying	bun
Foot,	dyinna	dyañ
Heel,	kunnak	blangdyañ
Paunch,	putye	buddhung gwanung
Blood,	kurk	gruk
Fat,	papul	wânuan
Bone,	kŭlk	bring
Penis,	berk	dhun
Glans penis,	kinninyuk-berk	
Foreskin,	mityubergo	-
Testicles,	mirrakbunya	durt
Pubic hair,	wurmuk	nirt gwunnung
Vulva,	ngula	williñ
Vagina,	berriadyuk	
Nymphæ,	baberguk	
Meatus,	dilluk	
Sexual desire,	tyiel	dyidwurrak
Erection,	duludya	kurugun
Copulation	tyanga	dhunguggan
Semen,	dyinyuk	
Emission,	kanganyin	
Masturbation,	buyurmullang	damut
Sodomy,	dyangamumuk	
Anus,	mum	

English.	Tyattyalla.	Brabirrawulung.
Excrement,	guna	gwunnung
Urine,	gir	wirrak
Venereal,	wambañ	wadyuwadyuk

Natural Objects.

English.	Tyattyalla.	Brabirrawulung.
Sun,	nyani	wurin
Moon,	mityen	weñ
Stars,	turt	brial
Pleiades,	mirgunyanguk	
Thunder,	murndar	gwurruñ
Lightning,	willimbak	mirrukwat
Rain,	mering	willungga
Dew,	gutyal	yarn
Fog,	gua	bauerndung
Frost and snow,	tanyeng	dhân
Hail,	ngek	
Water,	kutyin	yarn
Stream,	ngullok	
Earth,	tya	wruk
Mud,	bik	
Stone,	kutyup	wallung
Sand,	gurak	watthurt
A hill,	burbuk	krungark
Range of hills,	gau	
Light,	yap	
Darkness,	buruñ	
Heat,	wurn wurn	
Cold,	mutmut	mirpak
Camp,	lah	nguya or bang
Fire	wanyup	thauar
Smoke,	buriñ	bauerndung
Food,	bunyim	lâk
Day,	nyaui yingune	wurin
Night,	buruñ	butgalak
Morning,	burpadya	

English.	Tyattyalla.	Brabirrawulung.
Evening,	ngukkoa nyaui	
A splinter,	parakinnang	
Hole in a tree,	mirr	
Leaves of trees,	dyira	
Flowers of trees,	bumbul	
Egg,	mirk	buyal
Honey,	kulamut	ngarrun
Pathway,	paring	wannek
Tail of animal,	berguk	
Shadow of tree,	ngaguk	ngauuk
Grass,	boaty	bŭn

Mammals.

Native bear,	budyanmum	kula
Dog,	gal	bâñ
Opossum,	wille	watthan
Kangaroo-rat,	dyallugar	bri
Native cat,	berik, nyammung	bindyallang
Rock-wallaby,	kapurt	dhâgwan
Flying-fox,		ngaian
Flying-squirrel,	duan	wârañ
Ringtail opossum,	bunya	blâng
Kangaroo,	mindyul	dyira
Wallaroo,	gore	
Platypus,	mabial	mallunggang
Porcupine,	yulawil	kauan
Water rat,	brapir	durblang
Wombat,		narrôt
Bandicoot,	bung	bembung and mennuk

Birds.

Crow,	wâ	ngarukal
Laughing jackass,	kurng-gurng	gwâk
Curlew,	wil	
Scrub turkey, mallee-hen,	lauan	
Plain turkey,	ngurrau	

ENGLISH.	TYATTYALLA.	BRABIRRAWULUNG.
Native companion,	kutyun	guragan
Pelican,	patyangal	buran
Swan,	kunuwar	giddai
Wood duck,	wallang	
Quail,	burunggai	
Eaglehawk,	wreppal	gwurnamurung
Emu,	kau-wir	maiaura
Common magpie,	koruk	glârt
Black magpie,	munyugil	
Black duck,	ngurre	wrang
Mopoke,	karduk	wakkung
Night owl,	karimôl	
Bronze-wing pigeon,	tâp	
Wonga pigeon,		dhabbak
Lark	witguk	
Rosella parrot,	kurkalli	
Common hawk,		deddyel
Blue mountain parrot,	gallingurt	wataty
Green leek parrot,	yuip	
Kingfisher,	dyirkuk	
Pee-wee,	dyimdyim	nanawan
Plover,	berret berret	birran birran
Grey crane,	banggar	galu
White cockatoo,	dyinnap	brêak
Ibis,		giwert giwert
Black cockatoo,	karwil	nganak
Pheasant		wuraial

Fishes.

Perch,	wirringgal	tambun
Frog,	din	dirdillak
Eel,		nuyang
Shark,		yelmerai
Leather-jacket,		ngât
Bream,		kain

English.	Tyattyalla.	Brabirrawulung.
Skip-jack,		kărch
Flathead,		brindhat
Large mullet,		burbaiang
Small mullet,		krinyang
Flounder,		purpin
Schnapper,		narbugang

Reptiles.

Tree iguana,	nganur	buddhaluk
Ground iguana,	watya	
Turtle,	buipur	ngeth
Water lizard,		tharawurt
Sleepy lizard,	wallŭp	gungwun
Small lizard,		balmburn
Black snake,	gurnwil	duinyerrak
Brown snake,	dyallan	dhurung
Carpet snake,	binggal	laualbirr

Invertebrates.

Locust,	langalanga	guyaguyak
Blow-fly,	pabidyik	ngurrun
House-fly	lewilliwil	
Louse,	munyu	niñ
Nit of louse,	mirraguk	dhanggu
Jumper ant,	kuyuwidurt	brukutti
Bull-dog ant,	lakil	dikbun
Greenheaded ant,	boruñ	
Maggot,	pidyik	gwannung
Tick,	leny	tanggo
Leech,		dundarrugan
March-fly		ngarwaty
Scorpion,	birgwil	
Mussel,	pityin	narndewan
Centipede,	dyinyawaruk	
Mosquito,	girgik	dirdik

Trees and Plants.

English.	Tyattyalla.	Brabirrawulung.
Any leaning tree,	yurkauil	bandubandu
Any dead tree,	kuyuwok	tauanni
A squeaking tree,		dirrat
A hollow tree,	wenyam	bingalang
Ti-tree,	bunu	bâluñ
Box-tree,	buluty	dakan
Stringybark,	dulang	yanggura
Wattle,		mârt
Ironbark,		burrui
Cherry-tree,	ballaty	ballat
Gum-tree,	bap	balluk
Mahogany,		binnak
Light-wood,		yauun
Red Gum-tree,	bial	
Mountain-ash,	yauôty	
Mallee,	molli	
Bullrushes,	butbut	buruk
Yam,	moonya	mlang
Ferns (bracken),		kuwañ
Mushroom,		burkinmurpuk
Raspberry,		riumba

Weapons, Ornaments, etc.

Tomahawk,	batyik	dhugan
Koolamin,	dorung	kulngak
Yamstick,	berkunni	kunniñ
Wood spear,	guyun	kulladuan
Reed spear,	dyâk	wâl
Spear-thrower,	kurrik	murriwan
Boomerang,	gattimgattim	wangin
Spear shield,	kirram	bamruk
Waddy shield,	butwil	durnmang
Club with nob,	wutwut	gudyurung
Hunting club,	brêbiñ	

ENGLISH.	TYATTYALLA.	BRABIRRAWULUNG.
Headband,	murumgini	
Girdle,	murum	
Kilt,	baindyum	
Net bag,	warak	buddhung
Canoe	yunguip	gri
Canoe paddle,		dyandhuk

Adjectives.

Alive,	murun	
Dead,	wikin	durdigan
Large,	gurung	kurelgatti
Small,	bahm	dhalliban
Tall,	tyuwung	nekkilmun
Short,	dulu	dugal
Good,	dhalguk	lên
Bad,	yattyang	dindin
Hungry,	wikan	mremunaty
Thirsty,	branggunyan	gwandu
Red,	kurkuk wurrung	gingirruk
White,	tardarnity	darbandruk
Black,	wurkirrim	ninbandurak
Jealous,	mumaian	
Lame,	ngauwerrangan	girdirrumbirrang
Merry,		gragabunnhit
Full,	dyunggoa	durnduruk
Quick,	yanguyangui	wudhur
Slow,	yanakbata	yardabannai
Blind,	nyimnyim	thulumi
Deaf,	murt wrimbul	burrat wring
Strong,	wungurilwil	dardigannai
Valiant,	tillit wutyuk	
Afraid,	bamba	dyinagan
Right,	dhalgan yuma	
Wrong,	yattyangga yuma	
Tired,	barranggaian	yardabanni

English.	Tyattyalla.	Brabirrawulung.
Blunt,	murt	ngulla ngurndhak
Fat (plump),	papuwil	
Lean,	yattyang	
Cold,	mutmut	mirpak
Angry,	kulian	yerrak
Sleepy,	tuaran	
Glad,	thalkaian	dhadyang
Sorry,	wurpa	dindin munadha
Greedy,	murtga	ngullagung
Grey-headed,	latyaburp	
Bald-headed,	birreburp	
Sick,	katyalang	muraty
Stinking,	buang	mepbillan
Pregnant,	bunyer	litguran
Hollow,	mirr	

Verbs.

Die,	ingunea	turtigatu
Eat,	dyakalangan	dhanadalak
Drink,	kupan	dhanadayarn
Sleep,	kumban	bendhan
Stand,	dyarrigan	dyettyan
Sit,	ngangan	nyin or bunnungan
Talk,	wureagan	thunganadhang
Tell,	kinyan	
Walk,	yanngan	yangan
Run,	berpan	rindhan
Bring,	managa	wannhai
Take,	managо	kurtba
Make,	tauak	dyirrumba
Break,	kalpan	
Beat or strike,	takak	bundhun
Wound,	bukurnan	dawalgan
Arise,	baiki	wurridyallumba
Fall down,	buiki	blakadyingin

English.	Tyattyalla.	Brabirrawulung.
Observe,	nyangari	taiagri or thaganai
Hear,	ngarangara	wunga
Give,	wuguk	yugwan
Love,	wurpa-wutyupek	wurinyannaty
Sing,	kigili	watwaty
Weep,	numilli	nuwan
Cook,	pauak	
Steal,	kunnandyak	dhauandyadugri
Request,	wamuk	warban
Blow with breath,	burunggak	
Climb,	warwi	tauatgulla
Conceal,	nyûrtak	bagwan
Jump or leap,	papgume	gindhan
Jump over,	kandoak	
Laugh,	wekki	kramban
Scratch,	bŭnga	wardaban
Forget,	ngangang ngaianun	ngulla gullendhan
Stare at,	nyukkai nyanga	mutthungan
Send,	dyarreminnan	wandyin
Shine,	bungaiyappo	
Suck as a child,	bapillang	
Suck a wound,	bapuk	
Scold,	tyallian	
Swim,	tyippa	wirragun
Search for,	yaka	wungan
Spit,	telguk	dhukbadhu
Smell,	ngarruban	mebbillan
Throw,	yunggan	braba
Roast,	pauan	dyibun
Whistle,	tirrumbilli	witbyun
Pretend,	ngulwel'ang	dyedboallan
Kiss,	wôndyarrang	dhurndhumba
Vomit,	krama	krŏnggwan
Dance,	wirwa	murndhan
Dives,	ngukki kutyinna	mirkwan
Sting,	kulinyuk	bûndan
Bite,	bûnda	
Touch,	trungangin	
Call,	kurndi	

THE MITIGATION OF FLOODS IN THE HUNTER RIVER.

By J. H. MAIDEN.

[*Read before the Royal Society of N. S. Wales, August 6, 1902.*]

I. INTRODUCTORY.

The floods in the Hunter River arise from different causes, making their manifestations felt in different parts of its course. For example, the 1857 flood was (I understand)

an Upper Hunter flood. The 1893 flood was of a different character. It arose from rain in the Lower Hunter, which was mainly confined to the eastern and southern slopes of the Main Range parallel to the coast, and thence sea-ward. The rain-clouds came, I understand, mainly from the south-east and contact with the range induced the downfall. Such a flood being local, no engineering or other skill applied to the Upper Hunter could affect matters. Recently I examined the Upper Hunter and its tributaries, with the view to see if, from the point of view of the forester, I can make any suggestions reasonably calculated to mitigate, to any degree, the disastrous effects of floods in the Hunter.

Although I have paid scores of visits to various parts of the river, I do not wish to assume that my knowledge of the stream is as perfect as I would like it to be. I have however, carefully used my opportunities of studying the Hunter River question, and can only express the hope that my suggestions may be considered, especially as I have no sensational panacea to offer. I travelled the district during the heavy rains of August 1899, when the creeks, such as Stewart's Brook and Moonan Brook, were raging torrents, making an instructive contrast to their present state; now (May 1902) they are creeks nearly without water. In that year I saw the banks abundantly fall in and my trip was therefore in a measure more instructive than in 1893, when one's opportunities for observation were very limited. At the same time I inspected the devastation of the 1893 flood as soon as travelling was possible, and am cognizant, in some slight degree, with its effects.

II. Geographical Notes.

Mr. Napier Bell in his report[1] says, "The Hunter Valley from the sea to very near the top of its watershed, is the

[1] "Flood Prevention in the Hunter River," Legislative Assembly, 1899, p. 3.

finest and most fertile valley I have seen, and I do not think there is any like it in these Colonies." It will be at once admitted that the valley is one of the most valuable heritages New South Wales possesses, and hence the interests at stake in its welfare are of no ordinary magnitude. The river rises in the Mount Royal Range and in very many parts of its length runs through rich black soil flats, some of them quite small, but in the aggregate amounting to a considerable area.

The Page River is an important tributary of the Hunter and there is much rich land on its banks. This river has been settled for many years and its banks show much evidence of erosion. Extensive washaways are evident between Muswellbrook and Denman. There are now large reaches in the river both here and in other places, and it is pitiable to see the deep sections of rich land doomed to fall into the river bed and be washed away at every fresh. The Hunter is every year becoming broader and shallower. In seasons of drought such as the present, this is a matter of special consequence, as the waste of water through increased evaporation must be enormous.

The Goulburn River is the most considerable tributary of the Hunter, which it enters on its right bank, near Denman. It is said that this river brings down a larger body of water than the Hunter at the place of their junction, and hence it is believed by some people that it is this river that causes the greater portion of the mischief at Maitland, etc. The Goulburn River silt is by no means all sandstone, *e.g.*, Bow Creek flows through rich volcanic soil for a large portion of its course. The Wybong Creek shows washaways like the Hunter River creeks; there appears to be no very serious erosion of the Krui (another tributary of the Goulburn) at present, although the river appears to be widening about Collaroy.

As regards Merriwa Creek, the banks have broken down and have carried the rich alluvial soil with them, as in many other places. The soil of Merriwa appears to be *sui generis;* it is of specially fine texture and hence can only be used for crops with difficulty. At present we have very few data enabling us to classify the soils of New South Wales; in a few years no doubt we shall have a "soil-map" of the State, and then it will be realized how valuable are many areas along the Hunter River and its tributaries.

III. The Situation—*Denudation.*

Coming to first principles, the beginning of streams and floods with which we are concerned is:—1. Rain falls more or less on the land. 2. Some sinks into the ground. 3. The balance drains away.

Thus a single paddock may be an object lesson in regard to forces at work in the whole of New South Wales, as I will endeavour to show presently. I shall seek to prove that our treatment of paddocks affords an illustration of the truth of the ancient saying to the effect that—

"Every act of man is the forerunner of a chain of consequences of which no one can foresee the end."

The natural forests on the rounded steep hills of the Upper Hunter have in many cases been destroyed, and the sheep and cattle tracks are everywhere in evidence, even in the steepest places. At the present time (May), these dry and dusty hills (near the source) are a pitiful sight, brown, vegetationless (apparently) although the sheep and stock looked well considering the season.

The innumerable sheep tracks are accentuated, and the ground everywhere is pulverised by the feet of the sheep wandering after the scanty herbage. When the rain falls much of this pulverised soil, carrying with it grass plants (latent) and seed of grasses and various forage plants must be washed into the creeks and again into the Hunter,

which becomes discoloured. As the country is nearly all rung it is to be hoped that many of these seeds will be arrested by the fallen timber.

As we proceed towards the hills from the water-courses, we come to the clay and sandy land and to the masses of undecomposed basalt, which have no manurial value but are a potentiality for future ages.

The poorer uplands can sometimes only be profitably used in conjunction with the rich flats on which they abut. This is clearly brought out in the evidence[1] in regard to the proposal of the late Mr. Price, to dam the Hunter below Denman. In fact, if we loose our flats, large additional areas will be thrown out of occupation.

The Outlook Serious.

My view is that it is only a matter of a brief historical period when unless preventive steps are taken, these rich river and creek flats will find their way into the Pacific Ocean. Some people, including men of great experience and careful thinkers, are, however, of a different opinion. They view the erosion with more or less equanimity, considering that what is taken off one bank is deposited on the other. Of course erosion is going on all over Australia, and to what extent compensating influences are at work is a question for geologists, but I believe the amount of loss far exceeds the gain.

I do not like the *laisser faire* argument as applied to the Hunter. It seems an argument analogous to that because there will always be evil in the world, efforts for the betterment of man's condition should be abandoned. As a matter of fact man's existence in the world is dependent on his maintaining an incessant warfare against what are called "the forces of Nature." As regards the particular case

[1] "Hunter River Floods Prevention," Minutes of Evidence, Parl. Stand. Committee Public Works. Questions 1128, 1385, etc., 1901.

now under consideration, it is of course, a matter as to how far expenditure of effort and money are justified by the results they secure.

Let us not act as if we were content simply for the agricultural flats to last our time and then "Après nous le déluge." Like the nuggets of gold, and the forest monarchs (now sadly diminishing) we convert into timber, human agency has done nothing to produce them. Let us not deal with these rich flats simply as if they are capital to be got rid of in a brief period, but rather let us act in the capacity of faithful trustees, realizing that maintenance of the property is expenditure that must be incurred, and that it is vital to the very existence of the property.

IV. Intelligent Control of Ringbarking.

Going back to ultimate beginnings, to the creeklets, the source of all the troubles is the indiscriminate ringbarking and cutting down of vegetation by individual owners. The ringing or felling of trees in paddocks is of course necessary, but the requirements of the natural drainage seem not to be considered. The consequence is that in the dry creeks rifts appear, which gradually widen and carry soil, often the best soil, into the creeks and so on *ad infinitum.* The remedy lies in the intelligent control of ringbarking. Where there is an even contour of the land the operation is usually safe enough, but directly the land shows widening depressions that may carry water to lower levels, then operations should be undertaken with caution, since the water goes along the line of least resistance. In every paddock there is a getaway for the water, or if not, the water will make one. This getaway is the weak point of the paddock or other tract of country, but very often it receives no special notice or consideration. The trouble is accentuated in rich lands simply because of the finer texture or friability of such soils.

The State of New South Wales is mainly made up of paddocks! The paddock is the unit in considering the effects of erosion. Much of the mischief has already been done, but intelligent conservation of existing and future trees has vast possibilities for good. It ought to be made penal to ringbark up to a certain distance from a water-course, or to cut down a River Oak on any of the rivers (water-courses), except under a special license only to be obtained after due enquiry. The reason of the suggestions is because improper ringing or felling affects the riparian owner lower down, and he has quite enough difficulties to contend with which are beyond human control, to be victimised by the ignorant act of his fellow man higher up the stream. I could give an instance where a man cut down river oaks to make culverts; the river oak timber is now perished, and if he had gone but a few yards away he could have got almost imperishable ironbark. He now has to repair his culvert, but his river oaks are gone, his banks are falling away where he removed them, and a larger culvert is now required. In the case of a casual labourer this would have been termed living from hand to mouth. In the present instance it is miserable expediency and opportunism unworthy of thinking men. If the result of acts like these would alone affect the doer, we could view the matter with complacency.

a. *Shelter for Stock should be adequate.*—Shelter for stock is necessary; a few acres of trees should be left and not an odd tree or two which die out. The ruthless cutting down or sapping of trees has its basis in self-interest. A man desires to get the fullest advantage out of his land, and until it comes home to him that he is acting against his own interest in not conserving sufficient trees he will blunder along. In my view the advantage of leaving adequate shelter for stock is so obvious as not to be arguable.

b. *Danger of cutting trees too near the water-courses.* —All over the State people have made a mistake in sapping too near the rivers and water-courses. The dry, dead timber at the edge of the water-course no longer holds the banks for the reason that their roots have shrivelled and decayed and have no gripping power. Then the tree gets top heavy and breaks down the banks, and the second chapter of mischief starts.

The innumerable creeks will doubtless require to be dealt with in any effective remedy for the mitigation of floods. There is evidence everywhere of broadening streams, of banks breaking down and good soil washed away. Apple *(Angophora intermedia)*, and River Oak *(Casuarina Cunninghamiana)*, doubtless filled these flats, and they have been removed in order to cultivate the rich land to the fullest extent. The denudation is going on in geometrical progression. There are farmers even in a small valley like that of the Page near Murrurundi, who have lost as much as 50 acres through breaking down of banks.

What we see in the small creeks is repeated in the big rivers, so this is not a local matter merely as regards the little creeks. With friable banks every fresh carries down soil to the lower levels, and the stronger the current of course the greater the debris. This tends to work destruction at the lower levels. By all means therefore let us encourage people to prevent the erosion of the land higher up. It is not only that land is lost by erosion, but the land becomes a motive power to destroy property lower down. Much of the silt that people complacently see deposited on their ground is of course the soil of some unfortunate cultivator.

The matter might settle itself eventually by there being no more friable material to be washed away from the upper lands. If one could estimate the percentage of "flats"

area which has disappeared since the advent of the white man on some of the Upper Hunter streams I think the result would be startling.

V. Deviation of Roads.

The annual cost to the Roads Department of deviations necessitated by washaways and repairs necessary by washaways, must be very considerable, and having made special enquiries, I find that many of these washaways are the direct result of the destruction by private owners of trees along the getaways for water. If the cost to the Roads Department and to private citizens of road deviations, (with culverts, etc.) necessary through the washing away of the banks of rivers and creeks in the Hunter Valley, were available, I think it would surprise a good many people.

If the Public Works Department were to select say 100 definite places, on rivers, creeks, and furrows in cleared land (what I might term "incipient creeks") and photograph them every year, for say 5 or 10 years, the results would be of the highest educational value. They would be of value to the whole State, for the phenomena of aqueous denudation are in operation everywhere, although the results may not be, in most places, so disastrous as on the Hunter.

VI. Falling in of Banks.

These friable rich soil banks of the Hunter and some of its tributaries fall to some extent wet or dry. In dry weather they crack and tumble into the bed of the stream because of their lack of cohesion. In wet weather the rain soaks them, expansion takes place, cohesion again fails and the result is the same. These banks are, in fact, in a condition of unstable equilibrium.

VII. Floods and Weeds.

Another aspect of floods often lost sight of is the havoc committed in the lower lands by the transmission of weed

seeds and plants to lower levels, *e.g.*, Nut Grass *(Cyperus rotundus)*, Yellow or Prickly Poppy *(Argemone mexicana)*, Yellow Indigo *(Cassia spp.)*, Bathurst Burr *(Xanthium spinosum)*, Yellow Thistle *(Kentrophyllum lanatum)*, Chinese Thistle *(Centaurea calcitrapa)* and other thistles and pests of various kinds. The undisturbed propagation of weeds in the bed of an upper creek thus means loss to any rich lands on a lower level. Therefore, although for engineering purposes the consensus of opinion is to work from Newcastle, my view as regards weeds prevention is to begin as high up the Hunter and its tributaries as possible. They not only float the seeds down, but nice rich silt to give the weed-plants a fair start in life.

VIII. Some Miscellaneous Factors in Erosion.

a. *Boulders.*—The small stones and boulders in the bed of a stream are set in motion by floods, and forming eddies etc., grind down the banks. Good rich basaltic land is very fine grained, and washes away readily. The stones which are always found in it more or less help to break it away. Sometimes they form masses of considerable weight. The black soil everywhere rests on a bed of gravel. The water gets underneath and through the black soil, these gravel-stones facilitating the circulation of the water and the disintegration of the superimposed soil.

b. *Dead trees.*—The dead trees and branches felled for stock, unless they are dry enough for burning before the floods come, do much damage. So many River Oaks (and other trees) have been cut down during the present drought, that if a flood comes soon, enormous damage will be done through these dead trees tearing down the creeks and rivers. Dead timber of course threatens the bridges and also churns up the banks and works destruction. The courses of creeks are so irregular and the water comes down so suddenly that a stream may become a succession of grinding whirlpools.

c. *Stock.*—I desire to emphasise the damage caused by the trampling of horses and cattle, and by the nibbling and eating out of all vegetation in drought seasons such as the present. Let each landowner have his special crossing places for cattle, such places to be so arranged and prepared that the minimum damage of banks may be secured. See page 119.

IX. Remedial and Preventive Measures.

a. *Control of Ringbarking* (see page 112.)

b. *Fencing.*—Let me insist upon the judicious fencing of banks to protect their edges from stock and other traffic. I look upon this as one of the most important factors in preventing the erosion of the banks of the Hunter.

c. *Embankments.*—At present, owners of houses and shops and farmers are put to an increasing expense in protecting their properties by means of stone, pile and paling embankments, but in many cases the methods they are adopting are those of Mrs. Partington sweeping back the ocean, for the floods get at the back of their fortifications, and the last stage is worse than the first. In many cases the owners have large areas of additional land and do not bother about the problems concerned in the erosion of river banks. The probability is that if a man had only 40 acres and he lost 10 by a washaway, he would become alarmed, while a large landowner might treat the matter with comparative indifference.

What we see in West Maitland,—houses perched on crumbling banks and left more or less stranded,—we see on a smaller scale, *e.g.*, at Murrurundi on the Page River and in many other towns and villages on smaller creeks. If the welfare of West Maitland were alone at stake, then it might be worth while to resume the town and to sell the site for farms. Of course no other place is so seriously affected by the floods, but it would be inequitable to tax

the whole State for the sake of one town. What really is at stake is the rich soil along the whole course of the river and we should do all we can to prevent this marrow of the country from being wasted.

d. *Chamfering the banks.*—I would recommend that the soft banks be chamfered in some places. Where soft banks overhang, as we see in many places, they fall over and tear away enormous quantities of soil. One sees the remains of trees in many of these banks, and they do damage in precisely the same way as do the imbedded boulders already referred to.

e. *Planting and conservation.*—It appears to be very necessary to educate the people not to destroy timber and other vegetation on the banks and in the beds of creeks, and in certain places to proceed with replanting. It is quite true that replanting may in many cases mean the utilization of good land; it is equally true that if remedial measures be not proceeded with there will eventually be no good land left to plant on at all. Planting close to the edge is, I reiterate, a mistake, and arises from a natural desire to make the most of the land, to cultivate as much as possible for crops or grass. But trees and other plants placed too near the edge of a friable bank may be a source of danger and not a real protection, since they may act as a lever to break down the banks.

1. *Natural bank protectors.*—Let us observe the interlacing and ramification of the roots of trees in good soil (such as these flats and river banks). It is very extensive and their mechanical action in arresting washaways is obvious. One can see evidence that the banks of the Upper Hunter streams were much more lined with trees than at present. In many parts of the Hunter and its tributaries one sees large river oaks (many of them past their prime) leaving no descendants to continue their work of bank pre-

servation. The young seedlings are palatable to stock and hence they are eaten out if they have free access to them. This points to the necessary precaution that stock should not have unfettered access to the bed of a stream, as if it were a public highway. The seedling oaks should be carefully conserved until they are out of reach of stock. Great numbers of river oaks have been cut down this year for fodder alone.

One lays especial stress on the value of the river oak for purposes of bank protection, for the reason that it has for ages been the natural bank protector of these streams, and has become largely adapted to its environment. At the same time the acquisition of these lands by the white man and his method of dealing with the banks and adjacent country, constitutes a marked change in the conditions, and it may be that other trees are even better than the river oak for the purposes of bank conservation. River oaks have not a large tap-root; they have rather flat, spreading roots which penetrate the rich soil and silt on the bed of gravel already alluded to. When this gravel becomes bared, as it does in so many places, the river oak heels over and falls into the stream just as a boulder does.

2. *Other bank-protectors* (exotic).—Here and there one finds that plants other than river oaks have been utilized to protect the banks. Willows are the favourites, and I think rightly so. They grow naturally on the banks of streams, and during the winter months propagate naturally or artificially by cuttings very readily. Thus a flood which breaks off branches is the means of establishing other trees lower down. Stakes of willow up to six inches in diameter may be driven into the banks near the water, and in an ordinary season may be relied upon to flourish. At Segenhoe there is about a quarter of a mile of *Nicotiana glauca*, a South American weed, under the steep bank, which has

great promise as a protector of the banks. It forms a dense scrub and prefers drier situations than willows. On the Upper Hunter the common Passion vine has been found useful, in connection with willows, as a bank protector. Doubtless other riparian owners pin their faith more or less on other plants.

My view is that on the Upper Hunter the main bank-protectors should be trees, on the Middle Hunter small trees or scrub, and on the Lower Hunter, where the banks are usually low and friable, I would recommend creeping shrubs, and grasses, and other plants with underground rhizomes. I therefore make the following suggestions of readily available plants for the districts stated.

3. *Plants recommended for Upper, Middle, and Lower Hunter.*—*A.* List of trees recommended for the banks of the Upper Hunter:

1. *Casuarina Cunninghamiana*, Miq. The "River Oak," which has been referred to in the body of this paper. It may form a very large tree.

2. *Angophora intermedia*, DC. and *A. subvelutina*, F.v.M. These are rough-barked "Apple-trees." They attain a large size on the flats liable to inundation. Natives of Eastern Australia.

3. *Podocarpus elata*, R. Br. The "She, Brown or Berry Pine" which flourishes best on the banks of some of our rivers.

4. *Melia Azedarach*, Linn. The "White Cedar." One of our few deciduous trees. It is a native also of Asia. It grows readily from seed, which it produces abundantly. While this grows readily on river banks and among débris it will flourish on the drier mountain sides where it may be necessary to develop a rapid forest growth.

5. *Tristania conferta*, R. Br. The "Brush or Bastard Box," which requires a good depth of moist soil for its full development. It is perhaps better known under its nursery name of "Lophostemon."

The following are exotic trees :—

6. *Acer negundo*, Linn. The "Box Elder" of the United States, a deciduous Maple which affords an excellent summer shade.
7. *Ailanthus glandulosa*, Linn. A native of Asia which has several merits. Goats and other animals do not enjoy browsing upon it. Not only will it grow on the banks of rivers and bind them with its suckering roots, but it is one of the few that will flourish in the almost pure sand of the coast and of the Hunter River estuary.
8. *Platanus orientalis*, Linn. The "Oriental Plane," native of Europe and Asia. A noble tree which can be propagated by cuttings or seeds.
9. *Populus angulata*, Ait. The "Water Poplar" of the Eastern United States, so called because of the damp situations in which it flourishes.
10. *Robinia pseud-acacia*, Linn. A native of the United States, and commonly known as "Acacia." It is remarkably tolerant to heat and cold, lack of moisture and plenty of it, and to poverty of soil. It will bind shifting sand.
11. *Salix babylonica*, Linn. The common or "Weeping Willow," which is perhaps the best of all trees for consolidating river banks. Its roots form a net-work which bind soil, it will grow by the very brink of a stream and its pendulous branches that are broken down by the floods and winds take root lower down the stream.
12. *Taxodium distichum*, Rich. The "Virginian or Swamp Cypress," which in its native country flourishes in

sour, undrained swamps. It is less tolerant in cultivation, but it flourishes on the banks of waters where its roots can have full play.

13. *Ulmus campestris*, Linn. The common "Elm," which is well worthy of introduction in the Upper Hunter Valley as a soil-binder.

B. List of small shrubs or scrub recommended for the banks of the Middle Hunter:—

1. *Buddleia madagascariensis*, Lam. A well known plant which forms a rapid growing, tall shrubby mass. It is readily propagated by cuttings.

2. *Commersonia Fraseri*, J. Gay. A tall native shrub which naturally grows on the banks of water-courses.

3. *Cudrania javanensis*, Trécul. The "Cockspur Thorn," also a native shrub which forms an impenetrable mass of dense growth well calculated to bind soil and prevent further destruction. Propagated by cuttings.

4. *Duranta Plumieri*, Jacq. A tall growing shrub from the West Indies which forms dense masses. Readily propagated by cuttings.

5. *Hymenanthera dentata*, R. Br. This is a tall native shrub which forms large masses in good soil in many places in our coast districts. In the Upper Hunter district it flourishes already in many parts, Moonan Flat, for example.

6. *Ligustrum spp.* The "Privets," of which there are several species and varieties. They are all more or less soil binders and can be readily propagated by cuttings.

7. *Lycium barbarum*, Linn. A "Box thorn" which is a well known hedge-plant. It is not particular as to soil or situation.

8. *Olea europea*, Linn. The common "Olive." It likes good soil, and although it prefers proximity to the sea, there are many places in the Middle Hunter where it will flourish. The wild Olive which yields but a poor fruit could be planted, but I would like to see truncheons planted of the best pickling and oil-yielding Olives obtainable.
9. *Polygala myrtifolia*, Linn. A shrub of moderate size from the Cape. Not of special merit.
10. *Salix aurea*, Salisb. (a variety of the Huntingdon Willow *S. alba*, Linn.). The "Golden Willow." Most willows are valuable for the purpose under reference.
11. *Tamarix gallica*, Linn. The "Tamarisk." A native of Europe and Asia, which is very tolerant as regards soil and situation. It grows readily from cuttings and is a well tested soil-binder, even of sand.

C. List of grasses, creeping shrubs, etc., recommended for the banks of the Lower Hunter:—

1. *Cynodon dactylon*, Pers. The "Doub" or common "Couch-grass" of Eastern Australia. It is an excellent soil or sand-binder, so well known as not to require extended notice at this place. This and the five grasses which follow form a dense turf.
2. *Panicum plicatum*, Lam. This is a broad leaved grass from Southern Asia, which forms a coarse turf when eaten down.
3. *Paspalum dilatatum*, Poiret. During the last few years this American grass has come into great prominence for grazing for dairy cattle. It and several other Paspalums are excellent sand-binders and should be encouraged on the Lower Hunter.
4. *Paspalum distichum*, Linn. "Silt grass" or "Water Couch." A native grass and a good soil-binder in moist situations.

5. *Stenotaphrum americanum*, Schrank. The well known "Buffalo Grass" of New South Wales. This is a native of America. The nearer the sea the more it flourishes and it will stand droughty conditions which will destroy many grasses.

6. *Andropogon Schimperi*, Hochst. A tussock grass from Abyssinia, which stools readily and which promises to be a valuable grass for New South Wales. I believe it will prove to be a valuable soil-binder for the Lower Hunter.

7. *Elymus arenarius*, Linn. The "Sea Lyme Grass" of Northern Europe and Asia. It and the Marram Grass are excellent sand-binders.

8. *Cortaderia argentea*, Stapf. (*Gynerium argenteum*, Nees.). The well known "Pampas Grass" of South America, which grows in large tussocks.

9. *Imperata arundinacea*, Cyr., the "Blady Grass" of Eastern Australia which is a most effectual soil-binder, though not like most of the grasses recommended, a useful fodder plant in addition.

10. *Psamma arenaria*, R. et S. The well known Marram grass of North Europe and North America. Its value as a sand-binder in Victoria and New South Wales has now been proved beyond question.

11. *Small Bamboos* of any species should be tried on the Lower Hunter. They spread from the roots and their tough stems are very tenacious of life.

12. *Arundinaria falcata*, Nees. One of the smaller Himalayan Bamboos recommended for soil-binding.

13. *Arundinella nepalense*, Trin. A New South Wales grass worthy of further experiment for the purpose indicated.

14. *Arundo donax*, Linn. This handsome "Bamboo Reed" is now well acclimatised in New South Wales and flourishes in moist situations. It is a good soil-binder.

15. *Arundo phragmites*, Linn., (*Phragmites communis*, Trin.) The "Bamboo Reed" of New South Wales and many other parts of the world. It grows naturally along the margins of lagoons and water-courses and its growth should be encouraged on the Lower Hunter. I believe it to be the "Small cane" referred to in the enclosed letter to me by Mr. Charles Ledger the well known South American traveller of "Cinchona Ledgeriana" fame:—"The valleys of the Sama and Locumba are somewhat like those of the Hunter. In the first (Sama) is situated 30 miles of sandy plains near Tacna (Peru). During Dec., Jan., Feb., and March (or rainy season) its river, increased by the rains in the interior, rushes down its course from W. to E. with great force, undermining the banks on both sides, carrying away in that manner acres of soil where the banks are not protected by rows of *small cane* growing to a height of 10 to 12 feet. This small cane breaks the force of the rushing waters, and thus the river overflows its banks without carrying away the soil as formerly. In the same way the valley of Locumba is protected, indeed all valleys so situated in Peru."

16. *Bambusa gracilis*, Hort. and *B. nigra*, Lodd. Two more small bamboos that I can recommend as bank-protectors.

17. *Cyperus alternifolius*, Linn. An ornamental sedge from Madagascar which flourishes in damp situations.

18. *Escallonia rubra*, Pers. A small shrub from Chili which might be tried as a bank-protector.

19. *Mesembryanthemum æquilaterale*, Haw. The well known "Pig's Face" of our coasts. A succulent leaved plant which is useful as a sand-binder where there is not much traffic over the plants themselves.

20. *Phormium tenax*, Forst. and *P. Colensoi*, Hook. f. Two species of the well known New Zealand Flax, which possesses considerable merit as bank-protectors.

21. *Plumbago capensis*, Thunb. A well known shrub which forms a dense bushy growth.

22. *Rhagodia hastata*, R. Br. and *R. Billardieri*, R. Br. Two of our salt-bushes that may be recommended as sand-binders in brackish or sea side situations.

23. *Rubia tinctorum*, Linn. The "Madder" of Europe, which forms a low, smothering growth. It is worthy of a trial as a soil protector.

24. *Lippia nodiflora*, Linn. A low-growing plant which forms a mat on nearly pure sand. It belongs to the Verbena family and has been found on the coast at Tuggerah Lakes and further north.

4. *Nurseries.*—Each land-owner should have his own nursery of trees, shrubs and etc. The River Oaks yield abundance of seed and they are easy to rear, and the raising of trees and other plants is not beyond the power of any intelligent citizen. If our people would only carefully consider the question, it would be better for themselves, better for gardeners and nurserymen, and better for the country generally. No one doubts the capabilities of our people as eradicators of vegetation; it should be brought home to them that it is to their advantage to act judiciously in a contrary direction.

X. Summary of Proposals.

I will now summarise my proposals for the mitigation of floods in the Hunter. They are not sensational, but they

are all practical, and if they be given a fair trial I think that it will be found that they are based on sound principles.

1. Intelligent control of ringbarking or felling. This is the beginning of all things, the attempt to get at the little rifts in the ground-surface that have such mighty consequences.
2. Repair of little incipient rivulets by gradual replanting or placement of obstructions (logs etc.).
3. Planting of Willows and other trees, shrubs, grasses etc.
4. Chamfering of the banks.
5. Fencing of banks.
6. Burning as much as possible of the dead timber and branches to prevent their finding their way into the water-courses and scouring the banks. There is an especial abundance of dead timber after a drought.

APPENDIX. I.—*Mountain torrents in Europe.*

I add a statement from one of the best modern works on forestry[1] in regard to flood mitigation in Europe. The mountain torrents are, as a rule, different in character from the Hunter River and some of the methods in vogue in Europe would be impracticable here on account of the expense. I repeat my advice "to meet the danger at its source." Let us guard against undue erosion by the creeklets and creeks, and the big river will largely take care of itself. I am only referring to floods which have their origin in the Upper Hunter.

"Private agency can usually do nothing or little to prevent floods. The action of the State is indispensable, as the cost of the erection and maintenance of the works necessary to secure this object is quite out of proportion to the value of the property on which they must be erected,

[1] Schlich's "Manual of Forestry," Vol. IV., page 501.

and the work of fixing the beds of mountain torrents and hill-sides in process of denudation must be carried out over a large area. The most effective measures depend on the management of the collecting areas of dangerous water-courses, *the main principle being to meet the danger at its source.* . . (the italics are mine, J. H. M.)

"Serious and successful action however, is being taken in France, Switzerland and the Tyrol, to counteract the causes of floods. The chief rules to be followed are:—
(*a*) Revetment of torrents and their feeders. By this means earth, gravel, and boulders are retained in the mountains. Works of the following nature should be designed in accordance with the nature of the locality, the characters of the torrents, the area of the collecting ground, and the funds available:—

1. Barricades of trees with their entire crowns thrown across the torrents.
2. Wattle fences across the bed of torrents.
3. Dams made of fascines or masonry, to cause the deposition of coarse material, to be constructed across the torrents at suitable distances.
4. Paving the bed of the torrent.
5. Wattle fencing on revetments along the banks of torrents to moderate the cutting action of the water."

APPENDIX II.—*Lessons to be learnt from some European Rivers.*

I now give other European instances of conditions more closely paralled to those of the Hunter River. The rivers Volga, Garonne, and Loire afford special lessons to us, and since the injudicious felling of trees is attended by evil consequences the wide world over, we should lay the lessons to heart in New South Wales. As I propose to deal with the subject of deforestation more fully on another occasion,

I must dismiss it with these cursory and wholly inadequate references.

"The Alps and the Pyrenees, exposed to the same treatment, have been similarly affected. The deforestation paralyses the development of the pastoral industries in these regions by lowering the limits of forest vegetation. The valleys are ravaged by a devastating erosion. Entire mountains slide down slowly, carrying with them the pastoral villages which they bear on their surface, accumulating ruin and disaster."[1]

"These processes do not affect the mountain alone. For, by the very fact of this deforestation, the rich plains of the Garonne and the Loire are subjected to disastrous floods which make the fate of agriculture in these regions very precarious. This state of things has not failed to arouse apprehension among the inhabitants. Researches with regard to the question have shown that the devastating character of these inundations is due to the destruction of the forests which formerly covered the Central Plateau and the Pyrenees. The waters, no longer absorbed and regulated by the forest vegetation, flow away on the surface in enormous and sudden waves. The débris thus carried away in vast quantities contributes to the formation of barriers and gives to the waters their destructive power.

"But the danger does not cease there. The navigation of the great rivers gradually silted up by this waste from the mountains is rendered very difficult. So much is this the case that even Russia, a country so uniformly flat, is threatened in the use of its great water-way, the Volga. The investigations ordered by the Russian Government have demonstrated that this is the result of the drainage

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[1] Demontez, "Traite pratique du reboisement etc." 2nd edition 1882. Also J. Croumbie Brown, *op. cit.*

of the marshes and the deforestation of the low hills which give birth to the river."[1]

APPENDIX III.—*An instance of denudation in the United States.*

I will conclude with a graphic account by Mr. McGee of the destruction going on at present to form the "bad lands" of the State of Mississippi. I do not think that truth has been sacrificed to fine writing and do feel that what has been taking place in the Mississippi Valley has its counterpart in the Hunter Valley, New South 'Wales. The quotation is from Bulletin No. 7 of the Forestry Division of the U. S. Department of Agriculture:

"With the moral revolution of the early sixties came an industrial evolution; the planter was impoverished, his sons were slain, his slaves were liberated, and he was fain either to vacate the plantation or greatly to restrict his operations. So the cultivated acres were abandoned by thousands. Then the hills, no longer protected by the forest foliage, no longer bound by the forest roots, no longer guarded by the balk and brush dam of the careful overseer, were attacked by rain-drops and rain-born rivulets and gullied and channeled in all directions; each streamlet reached a hundred arms into the hills, each arm grasped with a hundred fingers a hundred shreds of soil, and as each shred was torn away the slope was steeped and the theft of the next storm made easier.

"So, storm by storm and year by year, the old fields were invaded by gullies, gorges, ravines, and gulches, ever increasing in width and depth until whole hill sides were carved away, until the soil of a thousand year's growth melted into the streams, until the fair acres, of ante-bellum days were converted by hundreds into bad lands, desolate and dreary as those of the Dakotas. Over much of the upland the traveller is never out of sight of glaring sand wastes where once were fruitful fields; his way lies sometimes in, sometimes between gullies and gorges—the "Gulfs" of the blacks whose superstition they arouse, sometimes shadowed by foliage, but oftener exposed to the glare of the sun reflected from barren sands. Here the road winds through a gorge so steep that the sunlight scarcely enters, there it traverses a narrow crest of earth between chasms scores of feet deep in which he might be plunged by a single misstep. When the shower comes he may see the roadway rendered impassable, even

[1] A. Woeikof. "De l'Influence de l'homme sur la terre." *Ann. de Geogr.* X., 1901 (Quoted by Marcel Hardy in *The Scottish Geogr. Magazine*, May 1902.

obliterated, within a few minutes; always sees the falling waters accumulate as viscid mud torrents of brown or red, while the myriad miniature pinnacles and defiles before him are transformed by the beating raindrops and rushing rills so completely that when the sun shines again he may not recognize the nearer landscape.

"This destruction is not confined to a single field nor to a single region, but extends over much of the upland. While the actual acreage of soil thus destroyed has not been measured, the traveller through the region on horseback daily sees thousands or tens of thousands of formerly fertile acres now barren sands; and it is probably within the truth to estimate that 10% of upland Mississippi has been so far converted into bad lands as to be practically ruined for agriculture under existing commercial conditions, and that the annual loss in real estate exceeds the revenues from all sources. And all this havoc has been wrought within a quarter of a century. The processes, too, are cumulative; each year's rate of destruction is higher than the last.

"The transformation of the fertile hills into sand wastes is not the sole injury. The sandy soil is carried into the vallies to bury the fields, invade the roadways and convert the formerly rich bottoms lands into treacherous quick sands when wet, blistering deserts when dry, hundreds of thousands of acres have been destroyed since the gullying of the hills a quarter of a century ago. Moreover, in much of the upland the loss, is not alone that of the soil, *i.e.*, the humus representing the constructive product of water-work and plant work of thousands of years, the mantle of brown loam, most excellent of soil stuffs, is cut through and carried away by corrosion and sapping leaving in its stead the inferior soil stuff of the Lafayette formation. In such cases the destruction is irremediable by human craft—the fine loam once removed can never be restored. The area from which this loam is already gone is appalling, and the rate of loss is increasing in geometric proportion."

A RAPID GRAVIMETRIC METHOD OF ESTIMATING LIME.

By F. B. GUTHRIE, F.I.C., F.C.S., and C. R. BARKER.

[Read before the Royal Society of N. S. Wales, September 3, 1902.]

IN the determination of lime in analytical work, this substance is almost invariably estimated, after separation from other metals, by precipitation as oxalate from an ammoniacal or acetic acid solution by means of ammonium oxalate. The precipitate, after thorough washing, is dried and ignited and estimated either as calcium oxide or as calcium carbonate. Ignition to oxide is the method most commonly adopted. The calcium oxalate precipitate requires strong ignition over the blowpipe for at least twenty minutes, and this must be followed by a further ignition over the blowpipe for 5 or 10 minutes in order to be certain that the weight remains constant. In cases where the precipitate is at all bulky, the complete conversion into oxide is a matter of considerable difficulty and a common practice is to ignite and weigh as carbonate. To do this, the oxalate is ignited at a low red heat. This operation is a very delicate and tedious one, and it is a very difficult matter to avoid converting some of the carbonate into oxide. In the event of this having taken place, the precipitate is moistened with ammonium carbonate solution, dried, and ignited at a heat only sufficient to drive off the excess of ammonium carbonate. Any calcium oxide formed by the first ignition is by this means converted into calcium carbonate.

This method has the disadvantage that it requires even longer time than the other, and involves three distinct operations; igniting, evaporating the ammonium carbonate

to dryness, and again igniting. The drying of the ammonium carbonate is an especially slow operation, as it has to be done at an extremely low temperature to avoid spurting.

If, however, ammonium nitrate is mixed with the calcium oxalate precipitate before ignition, calcium nitrate is formed which is readily and completely converted into oxide on ignition. Five minutes heating over an ordinary bunsen burner is quite sufficient for the purpose.

The details of the process are as follows:—The calcium oxalate, precipitated, washed and dried in the usual way, is introduced into a platinum crucible together with the incinerated filter-paper. Ammonium nitrate, previously dried at 100° C. and powdered, is added in the proportion of about 0·3 grms to every 0·2 grms of calcium oxalate and mixed as thoroughly as possible with a platinum wire or spatula. Heat must be applied very cautiously as the decomposition is rather violent, and the following precautions are to be observed. The crucible is placed in a slanting position and partially covered with the lid, in such a way as to prevent any possible spurting, and at the same time to allow of the contents being under observation. The flame of a bunsen burner is applied *to the lid* until the mass fuses and solidifies. By this means it is very easy to regulate the heat so that spurting or violent boiling is entirely prevented. The operation, using ·1 to ·2 grms oxalate and ·3 grms ammonium nitrate, takes from 4 to 6 minutes. The flame is then placed under the crucible for about 5 minutes longer, the entire operation taking about ten minutes. The whole of the calcium salt is converted into oxide, further ignition over the blowpipe being unnecessary.

In order to test the accuracy of the method, determinations were made by the process described, taking pure anhydrous calcium oxalate, with the following results:

Weight of anhydrous CaC_2O_4 taken.	Weight of CaO obtained.	Weight of CaO calculated from CaC_2O_4.
·0980	·0428	·0428
·0942	·0410	·0412
·1114	·0486	·0487
·0860	·0376	·0376
·0964	·0420	·0421
·0823	·0360	·0360
·0779	·0340	·0340
·2614	·1140	·1143
·2030	·0888	·0888
·1624	·0708	·0710
·3104	·1358	·1358
·3240	·1416	·1417

In the cases where the weight of oxide obtained differs from the weight calculated, the latter weight is always greater than the former, a difference which is undoubtedly to be attributed to the absorption of water by the anhydrous oxalate either during the process of weighing or in the desiccator.

In all the above determinations the amount of ammonium nitrate used was 0·3 grms, with the exception of the two last (over ·3 grms oxalate) in which cases 0·4 grms nitrate was taken.

W. H. Hess[1] has described a method for the estimation of lime in which a mixture of ammonium nitrate and ammonium sulphate is employed, the lime being converted into sulphate in which form it is weighed, the addition of ammonium nitrate rendering the conversion into sulphate rapid and certain.

Ignition in a covered crucible with ammonium sulphate alone is recommended by Schrötter,[2] the lime being weighed as sulphate. Fresenius also[3] recommends, after strong ignition of the oxalate, the addition of a little water and solution in HCl. Strong sulphuric acid is then added in excess, evaporated to dryness and ignited. The oxalate is thus converted into sulphate, in which form it is weighed.

1 Journal of the American Chemical Society, Vol. xxii., (1900) p. 477.
2 Fresenius Quantitative Analysis, Vol. i., (seventh edition) p. 188.
3 *Loc. cit.*

LANGUAGES OF SOME NATIVE TRIBES OF QUEENSLAND, NEW SOUTH WALES AND VICTORIA.

By R. H. MATHEWS, L.S.,

Corres. Memb. Anthrop. Soc., Washington, U.S.A.

[*Read before the Royal Society of N. S. Wales, September 3, 1902.*]

SYNOPSIS.—Prefatory. Grammatical structure of the following Australian languages:

Queensland—1 Yualeai. 2 Pikumbil.

N. S. Wales—3 Kawambarai. 4 Wongaibon. 5 Kūrnū. 6 Tyakē or Mystic Language. 7 Dyirringañ.

Victoria—8 Yotayota. 9 Burēba.

Comprehensive Vocabularies of Kūrnū, Yualeai and Yotayota words.

IN the following pages it is intended to exhibit the grammatical structure of the languages of some tribes in southern Queensland, in the central districts of New South Wales, and in the northern frontier of Victoria, the whole being the result of my own personal researches in the camps of the natives. It is hoped that work of this character will be found of some value to philologists by enabling them to compare the aboriginal tongues of Australia not only among themselves, but with others in different islands of Polynesia, Melanesia, and various parts of the Pacific Ocean.

In two papers[1] recently contributed to this Society I have described the constitution of the native tongues in the south-east corner of South Australia, the whole of Victoria, and the south-east coast of New South Wales

[1] "The Aboriginal Languages of Victoria," with Vocabularies.—Journ. Royal Soc., N. S. Wales, Vol. xxxvi., pp. 71 - 106. This paper explains the grammatical constitution of six Victorian languages.

"The Thurrawal, Gundungurra, and Dharruk Languages," with Vocabulary, *op. cit.*, Vol. xxxv., pp. 127 - 160.

from Cape Howe to the Hawkesbury River. The article now submitted is representative of the speech of the aboriginal tribes from the northern frontier of Victoria through a wide zone of central and western New South Wales, extending into the southern portion of Queensland at least as far as Maranoa and Burnett Rivers.

The system of orthoepy adopted in this paper is the same as that in my article on "The Aboriginal Languages of Victoria," with the following exceptions:

In the present paper, when the long sound of *a*, *e* and *u*, might be uncertain, these letters are marked thus, ā, ē, ū. In certain cases also where the short sound of *u* might be doubtful if unmarked, it is shown thus, ŭ. As far as possible, however, these vowels are not marked.

The usual arrangement of words in a sentence is to place the subject first, then the direct object, and lastly the verb. The indirect object often follows the verb. An adjective qualifying either the nominative or objective, follows the noun. A native speaker puts himself in the time of the event he is narrating; and when it is necessary to quote some person's statement, instead of saying, for example, "Tom told me so and so," he changes the tone of his voice, and repeats the other man's words as nearly as he can. An assertive sentence does not differ in form from an interrogative one, but the distinction is indicated by the modulation of the voice of the speaker.

There are no words, properly so called, corresponding to the English articles *a* and *the*. A blackfellow does not trouble about the abstract idea of a man, a tree, and so on. He speaks of some definite man or tree. The demonstrative pronouns in their various forms supply the place of the definite article. The adverb *here* and its variants, except when used predicatively, is treated in native speech

as a demonstrative, and is then another substitute for the definite article.

1—The Yualeai Language.

The natives speaking this language are located upon a tract of country in southern Queensland, including the Bokhara. Birrie, Narran, Ballonne and Moonie Rivers, and extend some distance within the New South Wales frontier, where they are met by the Kamilaroi nation. The Yualēai have the same initiation ceremonies as the Kamilaroi, consisting of the *Bora* and its impressive rites, which have been fully described by me in several scientific journals.[1] The social organization among the Yualēai is also the same as that of their Kamilaroi neighbours. The people are segregated into four divisions called Murri, Kubbi, Ippai and Kumbo, which intermarry in conformity with prescribed regulations. Details of this organisation have been given by me in various publications.[2]

Mr. E. M. Curr, published vocabularies of some dialects in this part of the country in his work.[3] No author has, however, hitherto attempted to promulgate the grammar of the language.

Nouns.

Nouns have number, gender and case.

Number.—There are three numbers, the singular, dual, and plural. Wan, a crow; wangali, a couple of crows; wanburala, several or many crows.

Gender.—In the human family gender is distinguished by using different words:—Urē, a man; inar, a woman. Men collectively are called dēn. Birralidyul, a youth;

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[1] "The Bora or Initiation Ceremonies of the Kamilaroi Tribe," Journ. Anthrop. Inst., Vol. xxiv., pp. 411 – 417; Vol. xxv., pp. 318 – 339.

[2] "The Kamilaroi Class System, etc.," Proc. Roy. Geog. Soc., Queensland, Vol. x., pp. 18 – 34. "Divisions of Australian Tribes," Proc. Amer. Philos. Soc., Philadelphia, Vol. xxxvii., pp. 152 – 154.

[3] "The Australian Race," Vol. iii., pp. 258 – 268.

mēadyul, a maid; wambundul, a child of either sex. Among animals, mundaia signifies a male, and gunidyarba a female —these words following the creatures' names.

Case.—The principle cases are the nominative, causative, genitive, dative, ablative, instrumental and accusative.

Nominative.—Gareme, a camp; burran, a boomerang; baura, a kangaroo.

Causative.—Urēu madhai bume, a man a dog beat.

Genitive.—Uregu burran, a man's boomerang; inaru dhibai, a woman's yamstick.

Dative.—Dhainhaia garemo, come to the camp.

Ablative.—Nhaia garemi, go away from the camp.

Instrumental.—This takes the same suffix as the causative:—Urēu wan burrndu gaiawi, a man at a crow a boomerang threw.

Accusative.—This is the same as the nominative.

It will be observed that the suffixes fluctuate according to the termination of the word to which they are attached. For example, urē takes *gu* in the genitive, whilst inar takes *u* only, for the sake of euphony.

ADJECTIVES.

Adjectives succeed the nouns they qualify, and take the same inflexions for number and case.

Nominative—Urē burul, a man large. Uregali burulali, a couple of large men, and so on.

Causative.—Urēu burulu burran wannunni, a man large a boomerang threw.

Genitive—Uregu burulu burran, a large man's boomerang; bauragu burulu dhun, a large kangaroo's tail.

Owing to the euphonic variations referred to in the declension of nouns, the suffix to burul in the two last

examples, is the same in the nominative as in the genitive, but any ambiguity which might arise from this cause is obviated by the differences in the suffixes to urē.

Dative.—Dhainhaia urēa burula, come to the man large.

Ablative.—Nhaia uredyi buruli, go away from the large man.

Adjectives are compared by saying, Gubba nha—guggil murra, good this—bad that.

PRONOUNS.

Pronouns are inflected for number, person and case, and contain two forms of the first person of the dual and plural.

Singular.

	Nominative.	Possessive.	Objective.
1st Person	Ngaia	Ngai-i	Ngunna
2nd ,,	Nginda	Nginnu	Nginnunna
3rd ,,	Ngu	Ngungu	Nha

Dual.

	Nominative.	Possessive.	Objective.
1st Person	Ngulli	Ngullingu	Ngullinya
	Ngulliyu	Ngullingubla	Nungullinya
2nd ,,	Ngindale	Nginalengu	Nginalinya
3rd ,,	Yuwari	Yuwaringu	Bulanga

Plural.

	Nominative.	Possessive.	Objective.
1st Person	Ngeane	Ngeanengu	Nganninno
	Ngeaneyu	Ngeninyella	Nganigunnunga
2nd ,,	Ngindeyu	Nginaingu	Nginnanya
3rd ,,	Gunnugu	Gunnungu	Gunnunga

The full forms of the pronouns given in the above table are chiefly used in response to interrogations, as for example "Who is here?" and some one answers "Ngaia." "Whose boomerang is this?" may elicit the reply "Ngai-i." Again, the question, "Whom did the kangaroo tear?" might be answered, "Ngunna." In ordinary conversation pronominal suffixes are employed.

Interrogative Pronouns.—Who (singular) ngana? Who (dual), ngananumma? Who (plural), ngangananumma?

Whom belonging to, ngangu? What, minya? What for, minyagu?

Demonstratives.—This, nha. That (near), ngule. That (farther), yuari. That (yonder), yurma. That (in front), murra. That (behind), murrabu. The demonstratives are many and diverse, and can be declined for number and case. A native will frequently indicate the position of anything by giving its compass direction from a tree or other known spot.

There are forms of the pronoun meaning "towards me," "away from me," etc. There is also a causative form, as, Ngaiala, I (will do it).

VERBS.

Ginye appears to have the meaning of "am," and can be used as a substitute for the English verb, "to be," by taking an adjective, wallun, or other suitable word, as in the following example. Dhu is the pronominal suffix representing "I" or Ngaia:

Present	Wallundhu ginye,	strong I am
Past	Wallundhu gillani,	strong I was
Future	Wallundhu gigi,	strong I will be

Imperative—Be strong! Wallun ginga.

In the subjoined conjugation of the verb buma, to beat, the present tense is given in full; but in the past and future, the first person only of the singular is taken:

Indicative Mood—Present Tense.

Sing.	1st Person	I beat,	Bumuldunnadhu
	2nd ,,	Thou beatest,	Bumuldunnindu
	3rd ,,	He beats,	Bumuldunnangu
Dual	1st Person	We, incl., beat,	Bumuldunnali
		We, excl., beat,	Bumuldunnaligu
	2nd ,,	You beat,	Bumullundhale
	3rd ,,	They beat,	Bumulbulaia
Plural	1st Person	We, incl., beat,	Bumuldunnane
		We, excl., beat,	Bumuldunnanēu
	2nd ,,	You beat,	Bumuldunnadai
	3rd ,,	They beat,	Bumuldunnagunnagu

In the past and future tenses there are forms of the verb representing differences in the time of the performance of the action. Examples in the first person singular of each tense will illustrate the principle of the inflexion.

Past Tense.

I beat a while ago,	Bumulngenyedhu
I beat yesterday,	Bumulmaianidhu
I beat, say a week ago,	Bumulēnyedhu
I beat long ago,	Bumulawailunnedhu

Future Tense.

I will beat presently,	Bumullidyu
I will beat tomorrow,	Bumulngēdyu
I will beat sometime,	Bumullingwullidyu

Imperative Mood.

Beat, bumulla! Beat not, wāl bumulla!

Conditional Mood.

Perhaps I will beat, Ya bumulliadyu.

There is no special form for the passive voice. The phrase, "a boy was stung by a scorpion," is expressed in Yualcai by the paraphrase, "A scorpion stung the boy."

Middle Voice—Indicative Mood.

Present	I am beating myself,	Bumulngildunnadhu
Past	I was beating myself,	Bumangildunnidyu
Future	I will beat myself,	Bumangilidyu

Imperative Mood.

Beat thyself, Bumulngilia.

Reciprocal—Dual.

Present	We are beating each other,	Ngulli bumullellunna
Past	We were beating each other,	Ngulli bumullellunni
Future	We will beat each other,	Ngulli bumullē.

Plural.

Present We are beating each other, Ngeane bumullellunna,

and so on. All the persons of the dual and plural take this inflection, by using the requisite pronoun.

There is an inflexion of the verb in several expressions to indicate whether two or more persons or things are spoken of, thus:

A couple talking, Gwallellunna
Several talking, Gwallawabŭldhunna
A couple sitting, Illauingillellunna
Several sitting, Illauawabŭldhunna
A couple running, Bunnagangillellunna
Several running, Bunnagawabŭldhunna
A couple fighting, Bumullellunna
Several fighting, Bumullawabŭldhunna
A couple standing, Wurringillellunna
Several standing, Wurriwabŭldhunna.

There are forms of the verb to express beating going along the road, beating before some event, after some event, after eating, and many others.

To beat again, Illaialu bumullui
To beat frequently, Illa bumuldhe

Adverbs.

Yes, nga. No, wal. Now, ila. Yesterday, gimmeanni. Tomorrow, ilāgingi. Bye and bye, ilala. Long ago, ilaluwangan. Always, ilalu. How, gullar? How many, minyangi? Where (singular), minyaia? Where (dual), minyaianda? Where (plural), minyaiandai? Here, nhē. There, ngare. Nhēngaia, here I am.

Prepositions.

In front, bunnidya. Behind, ngaiga. Inside, muddhuga. Beside me, mirrunda. Outside, wuggidya. Between, biddyunda. Down, nguddali. Up, ngurribali. Other side, gŭndar. This side, nuggili. Through, wōanha.

Exclamations.

Yah! calling attention. Wai! look out. Winnungga! listen. Ngarrarbang! pity.

Numerals.

One, millan; two, bullar; several, burala.

See the vocabulary of Yualeai words at the end of this article.

2—The Pikumbil Language.

The Pikŭmbil tribes are located on the Weir and Macintyre Rivers, Queensland; they adjoin the Yualeai on the east, and speak a dialect of the same tongue. Their initiation ceremonies[1] and divisional systems[2] are the same as the Kamilaroi, who adjoin them on the south.

I formerly resided some years in Goondiwindi, Queensland, in the Pikumbil territory, and had exceptional facilities for studying the geographic range of the dialects of their language. Travelling on one occasion from Goondiwindi to Miles, Gayndah and Maryborough, and returning by Ipswich and Leyburn, I found the fundamental elements of the native speech throughout was essentially the same, although differing more or less in vocabulary.

The initiation ceremonies[3] of the Dippil, Turubul and other tribes in the country just referred to are described in a paper contributed by me to the Anthropological Society at Washington, U.S.A. Particulars of their social organization[4] are given in articles I communicated to this Society in 1898, and also to the American Philosophical Society at Philadelphia the same year. Rev. Wm. Ridley gives a brief vocabulary of Pikumbil words.[5]

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[1] "The Bora of the Kamilaroi Tribes," Proc. Roy. Soc., Victoria, Vol. IX., N.S., pp. 137 - 173.

[2] "The Totemic Divisions of Australian Tribes," Journ. Roy. Soc. N. S. Wales, Vol. XXXI., pp. 156 - 171.

[3] "The Toara Ceremony of the Dippil Tribes of Queensland," American Anthropologist, Vol. II., N.S., pp. 139 - 140.

[4] "Australian Divisional Systems," Journ. Roy. Soc. N. S. Wales, Vol. XXXII., pp. 81 - 82; "Divisions of Queensland Aborigines," Proc. Amer. Philos. Soc., Vol. XXXVII., pp. 328 - 331.

[5] "Kamilaroi and Other Australian Languages," (Sydney, 1875), pp. 59 - 60.

A few examples of nouns, adjectives, pronouns, verbs, and adverbs are given below:

NOUNS.

The number, gender and case of nouns are so nearly the same as the Yualeai and Kamilaroi that little remains to be said. Mial, a man; thamar, a woman. Miallu mirri bumea, a man a dog beat. Mirrigu dhun, a dog's tail.

ADJECTIVES.

Adjectives are placed after the nouns they qualify and are declined for number and case. Comparison is effected in a manner similar to the Yualeai.

PRONOUNS.

Pronouns have the singular, dual and plural numbers and are without gender. There is an inclusive and exclusive form of the first person of the dual and plural. The singular number of the nominative and possessive pronouns are as under:

1st Person	I, Ńguttha	Mine,	Nger
2nd ,,	Thou, Nginda	Thine,	Nginnu
3rd ,,	He, Nhumbo	His,	Nhumbaga

Interrogatives—Ngana, who? Minya, what?

VERBS.

Verbs have the same numbers as the pronouns. There are modifications of the verb-endings to express recent and more remote periods of past and future time, the same as in the Yualeai and Kamilaroi. One example in each tense is given:

Present Tense.

Singular 1st Person, I am beating, Bumunguttha

Past Tense.

Singular 1st Person	I beat just now,	Bumŭguttha
	I beat this morning,	Bumulganibattha
	I beat recently,	Bumulbyēntha

Future Tense.

Singular 1st Person	I will beat presently,	Bumulluttha
	I will beat tomorrow,	Bumulngētha
	I will beat some time,	Bumulngurritha

ADVERBS.

Yuka, no. Pika, yes. Wanda, where? Certain adverbs, nouns and prepositions of the Yualeai, Pikumbil, and Kawambarai, are subject to inflexion for number and person, in the same manner as in the Wongaibon.

NUMERALS.

Dharrar, one. Buta, two.

3.—THE KAWAMBARAI LANGUAGE.

This dialect of the Kamilaroi language is spoken on the Barwon River about Bogabilla, Boobera, and Tulloona, New South Wales. The Pikumbil people adjoin the Kawambarai on the north-west, and the Yukumbil[1] on the south-east. The Kamilaroi tribes meet them on the south.

NOUNS.

The number, gender and cases of the nouns are so nearly identical with the Kamilaroi, that they will be omitted.

ADJECTIVES.

Adjectives are inflected for number and case like the nouns with which they are used.

PRONOUNS.

As the pronouns resemble the Yualeai, an example of the nominative case only is given:

Singular	1st Person	I,	Ngaia
	2nd ,,	Thou,	Ngindu
	3rd ,,	He,	Nguru
Dual	1st Person	We, incl.,	Ngulli
		We, excl.,	Ngullinguru
	2nd ,,	You,	Ngindale
	3rd ,,	They,	Ngurugale

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[1] See my "Yookumbil Language," Queensland Geographical Journal, Vol. VII., pp. 63 – 67.

Plural	1st Person	We, incl.,	Ngeane
		We, excl.,	Ngeaneyel
	2nd ,,	You,	Ngandai
	3rd ,,	They,	Ngurugunnugu

VERBS.

The principal parts of the verb bumulla, beat, are represented in the following conjugation. An abbreviated form of the pronoun is added to the verb stem, to indicate number and person. The whole of the present tense is given, but only parts of the others:

Indicative Mood—Present Tense.

Singular	1st Person	I beat,	Bumuldadhu
	2nd ,,	Thou beatest,	Bumuldandu
	3rd ,,	He beats,	Bumuldanguru
Dual	1st Person	We, incl., beat,	Bumuldali
		We, excl., beat,	Bumuldalinguru
	2nd ,,	You beat,	Bumuldandale
	3rd ,,	They beat,	Bumuldagale
Plural	1st Person	We, incl., beat,	Bumuldanē
		We, excl., beat,	Bumuldaneyel
	2nd ,,	You beat,	Bumuldandai
	3rd ,,	They beat,	Bumuldunnugu

Past Tense.

1st Person Singular	I beat, indefinite	Bumidhu
	I beat this morning,	Bumulngaindhu
	I beat yesterday,	Bumulmiēndhu
	I beat recently,	Bumullēndhu

Future Tense.

1st Person Singular	I will beat presently,	Bumullidyu
	I will beat tomorrow,	Bumulngedyu
	I will beat, indefinite	Bumullingurridyu

Imperative Mood.

Bumulla, beat!

If we direct one or more to do the beating, we could say, Bumullandu, beat thou! Bumullandali, beat you two! Bumullandai, beat you all! The prohibitive expression would be, Kurria bumulla, beat not. For the dual and

plural the suffixes in the last example could be used. Or, these suffixes could be applied to the negative instead of to the verb, thus: Kurriandu bumulla, beat thou not! Kurriandale bumulla, but not you two! Kurriandai bumulla, beat not any of you!

Conditional Mood.

Perhaps I will beat, Bumulliyadhu.

Reflexive.

I will beat myself, Bumaingilidyu.

Reciprocal.

We, dual, excl., are beating each other, Bumullellangura
We, plural, excl., ,, ,, Bumullellaneyel.

ADVERBS.

Kawam, no. Yo, yes. Thulla, where? Yelladu, now. Yirralo, by and bye. Ngurago, tomorrow. Yawawunna, perhaps. Kullier, quickly. Muru, well. Ngana, who? Minya, what? Minyangai, how many? Ngua, here. Nungarregi, there. The adverbs "here" and "there" often have the meaning of "this" and "that." When used in such sense, they serve the purpose of the definite article.

PREPOSITIONS.

Biddhun, between. Wurre, in front. Boadhe, behind. Kubbarunda, on top.

INTERJECTIONS.

Ngibai, surprise! Ngurragadhul, pity. Burrē, to break wind, *(flatus per anum)*, is often done as an interjection in the middle of a conversation, and provokes merriment among both sexes of all ages.

NUMERALS.

One, mal. Two, bular. Three, guliba.

4.—THE WONGAIBON LANGUAGE.

The territory of the Wŏngaibon tribe extends from about Booligal up the Lachlan River to Uabbalong; thence to

Nyngan, Cobar, Paddington, and Ivanhoe. Their initiation ceremonies are of the Burbung type in force among the Wiradhuri tribes, who adjoin them on the east, comprehensive descriptions of which have been given by me elsewhere.[1] The Wŏngaibon community is divided into four sections in the same manner as the tribes last mentioned, and similar laws regulate their intermarriages. I have explained the Wiradhuri organization in previous papers to this and other Societies.[2]

NOUNS.

The number, gender and case of nouns are as follows: –

Number.—The dual and plural are shown by suffixed particles: Singular, murrawe, a kangaroo; dual, murrawegale, a couple of kangaroos: plural, murrawebunggo, several kangaroos.

Gender.—Gender in the human family is denoted by different words. A man, thurgala. A woman, wirringga. A small girl, winnarga. Burai, a boy. Warru, a child of either sex. Men collectively are called maii. In speaking of animals, sex is distinguished by the addition of separate words for male and female respectively. Bidyer, a male; gunal, a female; papa, a cock; gūnni, a hen. These words are placed after the name of the animal whose sex they indicate.

Case.—The cases are the nominative, causative, genitive, accusative, instrumental, dative and ablative.

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[1] "The Burbung of the Wiradhuri Tribes," Journ. Anthrop. Inst., Vol. xxv., pp. 295 - 318; *op. cit.*, Vol. xxvi., pp. 272 - 285. Proc. Roy. Soc., Queensland, Vol xvi, pp. 35 - 38. "The Burbung of the Murrumbidgee Tribes," Journ. Roy. Soc. N.S. Wales, Vol. xxxi., pp. 111 - 153. "Initiation Ceremonies of the Wiradjuri Tribes," American Anthropologist, Vol. iii., N.S. pp. 337 - 341.

[2] "The Wiradjuri System," Journ. Roy. Soc., N. S. W., Vol. xxxi., pp. 171 - 176. "Australian Class Systems," American Anthropologist, Vol. ix., pp. 411 - 416; Vol. x., pp. 345 - 347.

Nominative.—Ngura, a camp. Mirri, a dog. Waru, a crow. Guragi, an opossum. Bulga, a boomerang. Kunni, a yamstick.

Causative.—Thurgalagu warru gumi, a man a child beat. Guragandu gira dhurra, an opossum leaves eats. Mirriga guragi gutthe, a dog an opossum bit.

Genitive.—Thurgallanggu ngura, a man's camp. Guraganggu dhun, an opossum's tail.

The possessive case of some nouns is shown by suffixing a particle corresponding to the person and number required as in the following table, which exhibits the inflection of ngura, a camp.

Singular	1st Person	My camp (camp my)	Nguranggadhi
	2nd ,,	Thy camp	Nguranggana
	3rd ,,	His camp	Nguranggalugu
Dual	1st Person	Our, incl., camp,	Nguranggaligi
		Our, excl., camp,	Nguranggaligini
	2nd ,,	Your camp,	Nguranggaunla
	3rd ,,	Their camp,	Nguranggullagula
Plural	1st Person	Our, incl., camp,	Nguranggangenigi
		Our, excl., camp,	Nguranggangenigini
	2nd ,,	Your camp,	Nguranggaungal
	3rd ,,	Their camp,	Nguranggalagugal

The foregoing words also have the meaning of "at my camp," etc.

Dative.—Thai nguranggu-yanna, the camp come to.

Ablative.—Ngurandi yannaidhi, the camp go from.

If two or more of anything be claimed, the inflexion of the noun would be:—Mirridhi, my dog; mirrigaledhi, my two dogs; mirribunggodhi, my several dogs; and so on through all the persons and numbers as above.

Adjectives.

Adjectives have the same numbers and cases as the nouns, and are placed subsequent to them: Thurgala bitthi,

a man large, Buppir, a very large man or any other thing. Thurgalagu bitthigu murrawe gumi, a man large a kangaroo struck. The suffix is often omitted from one of the words, leaving the noun only, or the adjective only, to indicate number or case, as, mirri bitthigu guragi gutthe, a dog large an opossum bit. Thurgallanggu bitthilalanggu bulga, a large man's boomerang.

The comparison of adjectives does not follow the same rules as in European languages, but one article is compared to another in this way: Yuttama nginya—wurrai ngunnai, good this—bad that. There are modifications in the case-endings of nouns and adjectives, depending upon the termination of the word declined.

PRONOUNS.

Pronouns have the nominative, possessive and objective cases as in the subjoined table. There are two forms in the first person of the dual and plural—one in which the person or persons addressed are included with the speaker, and another in which they are exclusive of the speaker.

Singular.

	Nominative.	Possessive.	Objective.
1st Person	Ngadhu	Ngutthi	Dhi
2nd ,,	Ngindu	Nginnu	Nu
3rd ,,	Nyillula	Igula	Lugu

Dual.

1st Person	Ngulli Ngullina	Ngulligi Ngulligina	Liggi Liggina
2nd ,,	Ngindunyula	Nginnula	Nula
3rd ,,	Nyillubulu	Igubala	Lugula

Plural.

1st Person	Ngeana Ngeanuna	Ngeanigi Ngeanigina	Ngeanaga Ngeanagina
2nd ,,	Ngindugal	Nginnugal	Nunggal
3rd ,,	Nyillugala	Igugulla	Nyuggala

Demonstratives.—Nginya, that. Nginyaga, that (in action). Nginyame, that (acted upon). The demonstratives are very numerous and varied, representing different gradations of meaning, depending upon the position of the object referred to in regard to the speaker, and also to the points of the compass. All the pronouns of the third person are in effect demonstratives, which accounts for their irregularity and diversity.

Interrogatives.—Ngandi, who? Ngangu, whose? Minya, what? Minyunggulmai, how many? Widdyūndugai, what's the matter? Widdhundu, how?

VERBS.

Verbs have the singular, dual and plural numbers, with the usual persons, tenses and moods. The verb stem and a contraction of the pronoun are incorporated, and the word thus formed is used in the conjugation. There is an inclusive and exclusive form in the first person of the dual and plural.

The following is a brief conjugation of the verb ngēli, to speak:—

Indicative Mood—Present Tense.

Sing. 1st Per.	I speak or talk,	Ngeradhu
,, 2nd ,,	Thou speakest,	Ngerandu
,, 3rd ,,	He speaks,	Ngeralula

Past Tense.

Singular 1st Person	I talked,	Ngelgaidhu
	I talked this morning,	Ngelngurrinyedhu
	I talked yesterday,	Ngelngunnidhu
	I talked recently,	Ngeldhumbirradhu
	I talked long ago,	Ngelgumbirngaldhu

Future Tense.

Singular 1st Person	I will talk,	Ngelagadhu
	I will talk presently,	Ngeladhullungadhu
	I will talk tomorrow,	Ngelngurriagadhu
	I will talk in the future,	Ngelwandhagadhu

Any person or number in each tense can be shown by using the necessary pronominal suffix.

Imperative Mood.

Singular	Ngea,	Speak (thou).
Dual	Ngealadha,	Speak (you).
Plural	Ngealagadugal,	Speak (you).

Conditional Mood.

Perhaps I will talk, Ngelagaiadhu

Reflexive.

I am talking to myself, Ngedyillingadhu.

Reciprocal.

We, (dual incl.) talk to each other, Ngelinnangulli

We (plural incl.) talk to each other, Ngelinnangēnna

If space permitted, all the above examples could be illustrated through the different persons and numbers.

Some verbs take a special inflection for number, which applies to actions in which two or more persons can take part, as in sitting, fighting, throwing, playing, etc., as in the following example :

Two talking, Ngeallanunnala

Several talking, Ngeallanunnuggal

The negative form of any verb is obtained by prefixing kurria, thus, Kurria ngea, speak not.

There are numerous modifications of verbs to express different shades of meaning, as: Wingurrimunnadhu, I sat all the time. Birrumburrayambuldhu, I throw (as a boomerang) in play.

Adverbs.

Yes, ngarbu. No, wŏngai. Now, dhallungurra. Yesterday, kumbirrangurra. Tomorrow, kumbirragulli. By and bye, dhallunggogulli. Long ago, ngurgambungarru. How, widdyu? How many, minyangalmai? Where, wŭndha? Where art thou, wŭndhalindu? and so on.

Prepositions.

Ngunagangura, behind. Willidya, in front. Waiangadha, around. Mugama, inside.

Some prepositions, like the nouns and adverbs, admit of inflexion for number and person, by affixing an abbreviated form of the pronoun:

1st Person	My left (left of me)	Miradhi
2nd ,,	Thy left	Miranu
3rd ,,	His left	Miralugu

All the persons in each number can be inflected.

Exclamations.

Wai! take care! Yah! calling attention. Chuh! silence. Any vocative can be inflected for number.

Numerals.

One, mukku. Two, bulagar. Several, bŭnggo.

As the Wiradhuri and Wongaibon are dialects of the same language, it will be interesting to introduce here a portion of the conjugation of the Wiradhuri verb buma, beat. A contracted form of the pronoun is suffixed to the root of the verb to show number and person. The present tense is given in full, but the first person of the singular will be sufficient to illustrate the past and future tenses.

Indicative Mood—Present Tense.

Singular	1st Person	I beat,	Bumarradhu
	2nd ,,	Thou beatest,	Bumarrawindu
	3rd ,,	He beats,	Bumarralula
Dual	1st Per.	We, incl., beat,	Bumarrali
		We, excl., beat,	Bumarraliguna
	2nd ,,	You beat,	Bumarrandubla
	3rd ,,	They beat,	Bumarragwainbula
Plural	1st Per.	We, incl., beat,	Bumarranē
		We, excl., beat,	Bumarraneguna
	2nd ,,	You beat,	Bumarrandugir
	3rd ,,	They beat,	Bumarragwainbulella

Past Tense.

Singular 1st Person	I beat this morning,	Bumulngurridyu
	I beat, yesterday	Bumulguandhu
	I beat, indefinite	Bumaidhu

Future Tense.

Singular 1st Person	I will beat, indefinite	Bumulgiridyu
	I will beat soon,	Bumulyamagiridyu
	I will beat tomorrow,	Bumulngurrigiridyu

Imperative.

Buma, beat! Kurria buma, beat not!

Reflexive.

Bumungadyillindyu, I am beating myself.

There are also reciprocal and other forms of the verb, but as I am preparing a grammar and vocabulary of the Wiradhuri language, no more will be said upon the subject at present.

5—The Kurnu Language.

The native tribes speaking the Kūrnū language are located on the Darling River from about Tilpa up the river to Bourke, and also up the Warrego River as far as Ford's Bridge. Dialects of the Kūrnū are spoken along the course of the Darling River from Tilpa downwards, viâ Wilcannia and Menindie, to Wentworth, a distance of about 350 miles. The Kūrnū language extends, with some modifications, from the Darling River to Torawotta Lake and the Barrier Ranges, as well as up the Paroo River as far as the Queensland boundary. The social organization and initiation ceremonies of these tribes were described by me in a former article to this Society.[1] The following elements of the language have been gathered by myself in the Kūrnū territory, from reliable old natives.

[1] "The Group Divisions and Initiation Ceremonies of the Barkunjee Tribes," Journ. Roy. Soc., N.S. Wales, Vol. xxxii., pp. 241 - 250.

Number.—Nouns have three numbers—the singular, dual and plural. Thurlta, a kangaroo; thurlta pakula, a couple of kangaroos; thurlta gutthalagu, several kangoroos.

Gender.—Wimbadya, a man. Burraka, a woman. Kuttyungga, a young boy. Karnkali, a young girl. Mundhanggura, a baby of either sex. The gender of animals is shown by affixing words indicative of male and female, as thurlta dhuladya, a male kangaroo; thurlta wambukka, a female kangaroo.

Case.—The following are some of the principal cases:—

The nominative indicates anything at rest, and is without flexion, as, kulli, a dog; wimbadya, a man.

The causative represents the subject in action, and takes a suffixed particle, as Wimbadyāwa waku burtatyi, a man a crow killed; kulliwa yerrandyi dhuttadyi, a dog an opossum bit.

Genitive.—Wimbadyana gattheri, a man's boomerang. Kullina gurni, a dog's tail. Burrakana kurnka, a woman's yamstick. The remaining cases are omitted.

ADJECTIVES.

These follow the nouns they qualify, and take the same inflexions for number and case. Wimbadya wurta, a man large. Wimbadyana wurtana gattheri, a large man's boomerang. Wimbadyawa wurtawa gattheri ngartatyi, a large man a boomerang threw.

Comparison of adjectives is effected by such expressions as "this is good—that is bad," and so on, in a similar manner to those of the Thoorga.[1]

PRONOUNS.

Pronouns have number, person and case. There are "inclusive" and "exclusive" forms for the first person of

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[1] "The Thoorga and Yukumbil Languages," Queensland Geographical Journal, Vol. XVII., pp. 49 - 73.

the dual and plural. The following table exhibits the nominative of the singular, dual and plural:

Singular	1st Person	I,	Nguppa
	2nd ,,	Thou,	Ngimba
	3rd ,,	He,	Wuttha or gitthu
Dual	1st Person	We, inclusive,	Ngulli
		We, exclusive,	Ngullingulu
	2nd ,,	You,	Ngupangalu
	3rd ,,	They,	Wutthawula
Plural	1st Person	We, inclusive,	Nginna
		We, exclusive,	Nginnanda
	2nd ,,	You,	Ngurtana
	3rd ,,	They,	Wutthēda

The possessive and objective pronouns are as under:

Singular	1st Person	Mine, Ngari	Me, Ngunnha
	2nd ,,	Thine, Ngoma	Thee, Ngumma
	3rd ,,	His, Watthunegi	Him, Wutthana

There are modifications of the objective pronouns to mean "towards me," "away from me," etc., as in the annexed examples:

Singular	1st Person	Towards me,	Ngunnhari
	3rd ,,	Towards him,	Gitthunari
Dual	1st ,,	Towards us, incl.,	Ngullinari
Plural	1st ,,	Towards us, incl.,	Nginnanari
Singular	1st Person	From me,	Ngunnarndu
	3rd ,,	From him,	Gitthanarndu
Dual	1st ,,	From us, incl.,	Ngullinarndu
Plural	1st ,,	From us, incl.,	Nginnanarndu

With me, or close to me, is Ngariri.

In each of the foregoing examples, the inflections can be applied to all the persons of the singular, dual and plural.

Interrogatives.—Who (singular), windyaka. Who (dual), windyula. Who (plural), windyi-windyi. Whose, windyakunnagi. What, minnha. What for, minnhamundi.

Demonstratives.—This, giki; that, wutthana.

VERBS.

Verbs have the same numbers and persons as the pronouns, with the usual tenses and moods. Tables of conjugations of verbs are omitted for want of space, but a tolerably full list of verbs will be found in the vocabulary. There are two forms in the first person of the dual and plural—the "inclusive" and "exclusive."

ADVERBS.

Yes, ngi. No, ngatthu. Here, kuugara. There, wurra. Yonder, wurrityalinnaga. To-day, kailpominka. Yesterday, yillana. To-morrow, wambinna. By and bye, kunnidilli. Long ago, kundindyi. In the future, windhuru. First, mirriga.

Where art thou, windyarra ngimba. Where goest thou, windyawarra dhani ngimba. How, nūnguna. How many, ngulthurra.

PREPOSITIONS.

In front, mirrika. In rear, ngunda. Between, bukkulu. Beside, gungo. Down, baikabika. Up, wunggalu. Inside, ngunggaru. The other side, murlăka. Outside, dhurnamurlaka. At my back, dhurna ngariri.

See the vocabulary of Kūrnū words at the end of this article.

6—THE TYAKE, OR MYSTIC LANGUAGE.

I have on several occasions reported the existence of a secret or cabalistic language used only by the men at the initiation ceremonies of several native tribes in New South Wales.[1] While the novitiates are away in the bush with the elders of the tribe, they are taught a mystic name for

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[1] Journ. Anthrop Inst., (1896) Vol xxv., p. 310. Proc. Royal Soc., Queensland, Vol. xvi., p. 37 Proc. Amer. Philos. Soc., Phila., Vol. xxxix., p. 471. Journ. Royal Soc., N.S. Wales, Vol. xxxii, pp. 249, 250. Congrès Internat. d'Anthrop. et d'Archéol. prehist., Compte Rendu, 12me Session, p. 491.

surrounding natural objects, animals, parts of the body, and short phrases of general utility. The language varies in different communities.

On the present occasion I am furnishing the names of several animals and a few other words, in the mystic language used among the initiated men of the Kūrnū tribe. The English words are given in the first column; the ordinary native equivalents in the second; and the secret or mystic words in the last column.

English.	Kurnu.	Mystic.
Kangaroo	Thurlta	Burnki
Black Opossum	Ngalkika	Kulla-niltillinya
Bandicoot	Burakunya	Wanganyalui
Porcupine	Yarrali	Kurlu-burlkali
Dog	Kulli	Munnidi
Grey opossum	Yerrandyi	Nguraninninyi
Padamelon	Murrinya	Yalĕngga
Kangaroo-rat	Gulatya	Burndali
Eaglehawk	Wurrigu	Wundamurra
Black duck	Ngultha	Barrimbarri
Curlew	Willaru	Kapimuku
Scrub turkey	Lauan	Mendhimugga
Diver	Ngurtadya	Burrakamuku
Teal duck	Kultaba	Mipperu
Wood duck	Gunali	Wundammur
Emu	Kulthe	Thittigilyu
Crow	Waku	Wakuburnki
Ground iguana	Burna	Mŭrnibungu
Tree iguana	Gugar	Munkamurra
Jew lizard	Gani	Wurrangura
Black snake	Kullali	Waiwai
Carpet snake	Bulthamuddyera	Kadhu
Penis	Wira	Mendiburnki
Testicles or scrotum	Mulu	Kurlu-burlkali
Vulva	Būlli	Kurla
Copulation	Bainngullana	Baingulla
Anus	Dhitti	Dhittimukku

It will be observed that some of the mystic names in the above list are formed from the common, by means of an additional word; thus, burnki is added to waku, the common native word for crow, to form the mystic name of that bird. Again, the porcupine is distinguished by the same name as the human scrotum. I have before observed obscenity connected with the porcupine in other tribes.

The following is a short list of words from the mystic language of the Kamilaroi tribe, which I collected when attending the Bora ceremony held at Tallwood in 1895[1]:—

English.	Kamilaroi.	Mystic.
Kangaroo	Bundar	Ungogirgal
Opossum	Mute	Birredburraburai
Dog	Buruma	Gungumoal
Eaglehawk	Thirril	Dhindhurringa
Emu	Dhinōan	Ungodhulli
Tree iguana	Yurundiali	Birridhunbillirnga
Carpet snake	Yabba	Milngulli
Penis	Dhun	Dhunburringa
Testicles	Buru	Būrumbunna
Vulva	Yangal	Wungodhe
Copulation	Thadha	Wunggogurrilli
Anus	Nyi	Murumburnge
Head	Koga	Kubbadhirba
Forehead	Ngulu	Ngulumblal
Hair of head	Kah	Budhubudhulnga
Eye	Mil	Millungga
Nose	Muru	Murunggun
Ear	Binna	Binnēyulaui
Mouth	Ngaih	Ngaimballumbu
Thigh	Dhurra	Gunnimbar
Foot	Dhinna	Gungu
Teeth	Yira	Yirambunna
Fire	Wi	Buddhamur
Smoke	Thu	Thugabil

[1] "The Bora of the Kamilaroi Tribe," Proc. Roy. Soc., Victoria, Vol. IX., N.S., pp. 137 - 173.

English.	Kamilaroi	Mystic.
Water	Kolli	Wungothubbil
Boomerang	Burran	Wanggaribŭl
A stone	Yarral	Wallamari
Father	Baina	Muddhamunna
Elder brother	Daidjhi	Muddhunga
Clever man,	Wirringan	Gundaidhar
A man	Giwir	Maimba
A woman	Inar	Winnilwanga
Behold!	Ngummilla	Unggomilli
Camp	Wullai	Nyimarai

In ordinary Kamilaroi conversation, kutthabultda is the noise made while copulating, and burrabunda means emission. If anything remarkable or jocular is being narrated, one or more of the hearers will exclaim "Kutthabulda!" or "Burrabunda!" or perhaps both words will be interjected by different persons. They are used indiscriminately by men and women.

7—The Dyirringan Language.

The remnants of the Dyirringañ tribe occupy the northern half of the county of Auckland, on the south-east coast of New South Wales. They are bounded on the north by the Thoorga-speaking people, whose language I have elsewhere dealt with.[1] On the south are the Thāwa and other tribes, whilst the Muddhang and Ngarrugu occupy the country to the west. Stretching southerly along the sea-coast from the Dyirringañ territory to Cape Howe, and onward into Victoria as far as Anderson's Inlet, into which the Tarwin River empties, in the county of Buln Buln, all the languages are similar in grammatical structure[2] to the Dyirringañ, although some of them differ considerably in vocabulary. I have also observed here, as in other districts, that two

[1] Queensland Geographical Journal, Vol. xvii., pp. 49 – 60.
[2] See my "Aboriginal Languages of Victoria," Journ. Roy. Soc., N. S. Wales, Vol. xxxvi, pp. 71 – 106.

dialects may differ widely in intonation, although the changes in vocabulary are comparatively slight, which gives the superficial observer the impression that they are altogether unlike.

The initiation ceremonies of the Dyirringañ are described in an article which I communicated to the Anthropological Society at Washington, U.S.A., in 1896.[1] In common with certain other tribes, their intermarrying laws, and the Kudsha ceremony, are also dealt with by me in a previous article to this Society in 1900.[2] The Dyirringañ is one of an aggregate of tribes whose sacred songs I have learnt and published, with the accompanying music, in a paper contributed to the Royal Geographical Society of Queensland.[3] These are the first sacred songs of the Australian Aborigines which have ever been set to music.

NOUNS.

There are three numbers—singular, dual and plural.

Number.—Baiil, a man; baiilwula, a couple of men; baiilma, several men.

Gender.—Mulidya, a woman. Baiil, a man. Būrru biangwa, a male kangaroo. Būrru ngigwa, a female kangaroo.

Case.—The principal cases are the nominative, accusative, causative, genitive, instrumental, dative and ablative. The nominative simply names the subject at rest, as, Baiil bagama, the man sits. The causative indicates the agent of a transitive verb, as, Baiillu wingal wammaba, a man a child beat.

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1 "The Bunan Ceremony of New South Wales," American Anthropologist, Vol. IX., pp. 327 - 344, plate vi.

2 "The Organisation, Language and Initiation Ceremonies of the Aborigines of the south-east coast of New South Wales," Journ. Roy. Soc, N. S. Wales," Vol. XXXIV., pp. 263 - 264, and 276 - 281.

3 "Aboriginal Songs at Initiation Ceremonies," Queensland Geographical Journal, Vol. XVII., pp. 61 - 63.

The possessive case is represented by a suffix to the name of the property as well as to that of the owner. Baiilla mirrigangwa, a man's dog. Mirriga wingalangwa, a dog's puppies. Anything over which possession can be exercised is subject to inflexion for number and person:

Singular	1st Person	My camp (camp my)	Badhaldya
	2nd ,,	Thy camp	Badhalnyi
	3rd ,,	His camp	Badhalwa

and so on through the dual and plural numbers.

Instrumental.—Wannungala yerrabandya warrangandu, who threw at me a boomerang. The accusative is the same as the nominative. Dative.—Ngurani, to a camp. Ablative.—Nguradyan, from a camp.

Adjectives.

Adjectives follow the nouns they qualify, and take the same declensions for number and case. They are compared as under: Jummaga nyan—dhauat nyanya, good this, bad that. Jummagumma nyanya, this is very good.

When an adjective is used as a predicate, it can, by applying the proper postfixes, be converted into a verb, as in the word mūndur, strong:

Singular	1st Per.	I am strong,	Mūndur-gaiamungga
	2nd ,,	Thou art strong,	Mūndur-gaiadyamung
	3rd ,,	He is strong,	Mūndur-gaiadyama

This inflexion extends to all the persons of the dual and plural, and to the past and future tenses.

Pronouns.

There is a distinctive form of the first person of the dual and plural, according as the individual spoken to is included or excluded:

Singular	1st Person	I,	Ngaialu
	2nd ,,	Thou,	Indigal
	3rd ,,	He,	Waralu

Dual	1st Person	We, inclusive,	Ngaianga
		We, exclusive,	Ngaiangulu
	2nd ,,	You,	Indigumbul
	3rd ,,	They,	Waraligimbula

Plural	1st Person	We, inclusive,	Ngaianyin
		We, exclusive,	Ngaianyilla
	2nd ,,	You,	Indiganyu
	3rd ,,	They,	Waraligima

The following are the possessive pronouns of the first person singular—the other numbers being passed over:

Singular	1st Person	Mine,	Ngaialunggulal
	2nd ,,	Thine,	Indigunggulal
	3rd ,,	His,	Waraliminyawa

There are two sorts of possessives—those which have just been mentioned, and those which are suffixed to a noun as badyaldya, my camp, exemplified in a previous page.

There are forms of the pronoun signifying "away from me," "towards me," etc., which need not now be particularised.

Demonstratives.—This, nyan; that, nyanya. These and other forms are very numerous, and are inflected for number and case, as in the Thurrawal and Thoorga, thus:—

Singular—Baiil mūndur nyanya, man large that.
Dual—Baiilwula mūndurwula nyangimbula, men large those
Plural—Baiilma mūndurma nyangima, men large those.

Interrogatives.—Wannunggal, who? Wannunggulal, whose? Minya, what? Minyanē, what for?

Pronominal suffixes, in abbreviated forms, are used in great number and variety in the declension of nouns, adjectives, verbs, prepositions, adverbs, and interjections; examples of which are given under these parts of speech in the present paper.

VERBS.

The verb "to be" has apparently a substitute in the word gaia, which is inflected for number and person.[1] If an

[1] "The Aboriginal Languages of Victoria," Journ. Roy. Soc., N. S. Wales, Vol. xxxvi., pp. 71 – 106.

adjective, adverb, or other suitable word be taken as a predicate, we get the example given in an earlier page, under the head of "Adjectives": Mūndur-gaia-mungga, strong am I, and so on.

Following is the conjugation of the principal elements of the verb wamma, to beat or strike:

Indicative Mood—Present Tense.

Sing.	1st Per.	I beat,	Wammamungga
	2nd ,,	Thou beatest,	Wammamangi
	3rd ,,	He beats,	Wammama
Dual	1st Per.	We, incl., beat,	Wammamunga
		We, excl., beat,	Wammamungalu
	2nd ,,	You beat,	Wammamumbul
	3rd ,,	They beat,	Wammamumbula
Plural	1st Per.	We, incl., beat,	Wammamunyan
		We, excl., beat,	Wammamunyilla
	2nd ,,	You beat,	Wammamunyu
	3rd ,,	They beat,	Wammamundya

Past Tense.

Sing.	1st Per.	I beat,	Wammabagga
	2nd ,,	Thou beatedst,	Wammabangi
	3rd ,,	He beat,	Wammaba
Dual	1st Per.	We, incl., beat,	Wammabanga
		We, excl., beat,	Wammabangalu
	2nd ,,	You beat,	Wammabambul
	3rd ,,	They beat,	Wammabambula
Plural	1st Per.	We, incl., beat,	Wammabanyan
		We, excl., beat,	Wammabanyilla
	2nd ,,	You beat,	Wammabanyu
	3rd ,,	They beat,	Wammabandya

Future Tense.

Sing.	1st Per.	I will beat,	Wammayābulla
	2nd ,,	Thou wilt beat,	Wammayibulla
	3rd ,,	He will beat,	Wammabulla
Dual	1st Per.	We, incl., will beat,	Wammangabulla
		We, excl., will beat,	Wammangūlabulla
	2nd ,,	You will beat,	Wammūlbulla
	3rd ,,	They will beat,	Wammūlabulla

Plural	1st Per.	We, incl., will beat,	Wammanyanbulla
		We, excl., will beat,	Wammanyulabulla
	2nd ,,	You will beat,	Wammanyubulla
	3rd ,,	They will beat,	Wammandyabulla

A negative meaning is given by means of an infix, ña, between the verb stem and the abbreviated pronoun:

Wamma-ña-mungga, I beat not, and so on, through all the parts of the verb.

Imperative.

There are affimative and negative forms of the verb:—

Singular	Beat, Wamma	Beat not, Wammanyāwi
Dual	Beat, Wammul	Beat not, Wammanyawul
Plural	Beat, Wammanyu	Beat not, Wammanyanyu

Conditional.

Perhaps I will beat, Wammayābulla-wanda, and so on for the rest of the persons and numbers.

Reflexive.

Present	I am beating myself,	Wammullimungga
Past	I did beat myself,	Wammullibagga
Future	I will beat myself,	Wammulliyābulla

This inflection applies to all parts of the verb.

Imperative-reflexive.

Singular	Beat thyself,	Wammulli
Dual	Beat yourselves,	Wammullul
Plural	Beat yourselves,	Wammullūnya

Reciprocal.

This form of the verb is of course restricted to the dual and plural:

Dual.

We, incl., are beating each other,	Wammullidyagunga
We, excl., ,, ,, ,,	Wammullidyagungalu

Plural.

We, incl., are beating each other,	Wammullidyaganyan
We, excl., ,, ,, ,,	Wammullidyaganyilla

Imperative-reciprocal.

Dual Beat each other, Wammadyagalul
Plural Beat each other, Wammadyagalūnyu

There are numerous modifications of the verb to convey different shades of meaning, a few examples of which may be given :—Wammabandya. struck me; wammaguban, struck thee. Warranganwai yellindyarria, a boomerang bring to me. Yellinyilliwai, bring this direction. Yellimungga, I carry or bring.

The verb takes an inflection for the same number as the object noun :

Būrru nyambugga, a kangaroo saw I.
Būrrula nyabugālu, a couple of kangaroos saw I.
Būrruma nyabugana, several kangaroos saw I.

Prepositions.

The equivalents of our English prepositions are in some cases separate words, but are also frequently expressed by a verb. A few short sentences will illustrate the application of these rules :—Bŭrru, between, or in the middle. Wurrananggi, the other side. Ngulụwan, in front. Garranggañ, behind. Irritgundi, inside. Nguttandya, outside. Gurrano, up (a river). Wullungurri, down (a river etc.). Nyaninggo, close.

The following verbs convey a prepositional meaning :—Dhumala dhurātyububugga, scrub through went I. Bungguri dhullibumungga, hill up go I. Bungguri nyirrumungga, hill down go I. Bungguri bullāwugūngga, hill on the side of go I, or I go on the side of the hill. Ngugangga yendinyellima, water across comes he.

Some prepositions can be inflexed for person and number:

Singular	1st Person	In front of me,	Nguluwandyia
	2nd ,,	In front of thee,	Nguluwandyin
	3rd ,,	In front of him,	Nguluwangung

and so on through the dual and plural numbers.

Adverbs.

The following are a few of the more commonly used adverbs:—Yes, ngāwe. No, thuggail. Today, munnago. Perhaps, wanda. By and bye, bulla. Long ago, warralingo. From yonder, warrabiggidyan. How, yua. Whither, wandyinni. Whence, wandyidyin. Soon, yunggo. How many, yuagailuma. What is the matter, minyanggūndu.

Certain adverbs can be inflected for number and person:

Singular	1st Person	Where am I,	Wandyia
	2nd „	Where art thou,	Wandyawili
	3rd „	Where is he,	Wandyawanni

and so on through all the persons, numbers and tenses.

Conjunctions.

The general absence of conjunctions is attributable to the numerous modifications of the verbs and pronouns, by means of which sentences are brought together without the help of connecting words. We sometimes find an intrusive letter or syllable used between words, to prevent hiatus, which serves the purpose of a conjunction.

Interjections and Exclamations.

These parts of speech are not numerous:—Calling attention, yai! in the singular; yaiawul! in the dual; yaianyu! in the plural.

Numerals.

One, mirdindhal. Two, dyirriba. Three, turungadya.

8—The Yota-yota Language.

This language is spoken by some small tribes on the Murray River, from Cobram for some distance below Echuca extending into Victoria as far as Shepparton, and into New South Wales to Deniliquin. On the south they are bounded by the Thaguwurru nation,[1] and on the north by the

[1] "The Aboriginal Languages of Victoria," Journ. Roy. Soc., N. S. Wales, Vol. xxxvi., pp. 71 - 106.

Wiradhuri, but the Yota-yota people have apparently kept their language distinct from those of their neighbours. On this account it is important from a linguistic point of view, and I consider myself fortunate in being the first to report its grammatical structure. Considerations of space will however, render it necessary to deal only with the fundamental elements of the language.

Mr. E. M. Curr, gave vocabularies of some tribes in this region in his work,[1] but he left the grammar of the language untouched.

The ceremonies of inauguration and the laws of intermarriage of this tribe, among others, are described in an article I contributed to the Anthropological Society at Washington, U.S.A., in 1898.[2]

Nouns.

Number.—Nouns have the singular, dual and plural. Buttya, an opossum; buttyal, a pair of opossums; buttyau, several opossums. Winyar, a woman; winyandyal, a couple of women; winyanboga, several women.

Gender.—There are two modes of indicating gender—by using different words for the masculine and feminine, or by adding words meaning male and female respectively. Yiyir, a man. Winyar, a woman. Nunyunbunna, a girl. Nyawoga, a maid. Dhuddhiwa, a girl. Who has just attained puberty. Yiyirram, a boy. Mālnega, a youth. Gudhupka or yarka, a child of either sex. Bukka nhalma, a male dog. Bukka nhana, a female dog. Baiamal nungea, a cock swan. Baiamal nhana, a hen swan.

Case.—The principal cases are the nominative, causative, genitive, dative, ablative, instrumental and accusative.

[1] "The Australian Race," Vol. III., pp. 570–589.

[2] "The Victorian Aborigines: their Initiation Ceremonies and Divisional Systems," American Anthropologist, Vol. XI., pp. 326–330, with map showing distribution of the native tribes of Victoria.

Nominative.—Wŭnya, a boomerang. Kangupka, a perch. Nukkin, the tail of an animal. Dungula, a river. Manung, a camp.

Causative.—Yiyirril wunya munnin, a man threw a boomerang. Winyarril kangupka mummun, a woman a perch caught. Bukkal buttya yinnin, a dog an opossum bit.

Genitive.—Yiyirrin wŭnya, a man's boomerang. Winyarrin nŭnyir, a woman's yamstick. Buttyan nukkin, an opossum's tail.

Dative.—Dungulung, to the river.

Ablative.—Dungulin, from the river. Manungyin, from the camp.

Instrumental.—Ngango yiyir wŭnyal munin, I at a man a boomerang threw.

Accusative.—The same as the nominative.

ADJECTIVES.

Adjectives are declined for number and case, and are placed after the qualified noun. Yiyir dunngidya, a man large. Yiyirral dunngidyal, a couple of large men. Yiyarrau dunngidyau, several large men. Yiyirril dunngidyil buttya tuttain, a large man an opossum killed. Yiyirrin dunngidyin wunya, a large man's boomerang.

The remaining cases are declined the same as the nouns. Comparison of adjectives is effected in a manner similar to that employed in the Thoorga.[1]

PRONOUNS.

Pronouns have three numbers and the usual cases. The first person of the dual and plural contains two pronouns, the first of which includes both the speaker and the party addressed, but the second excludes the party spoken to. These are marked "incl." and "excl." respectively. Some

[1] "The Thoorga Language," Queensland Geographical Journal, Vol. XVII., pp. 49–73.

of the nominative and possessive pronouns are as here tabulated:

Singular	1st Person	I, Ngango	Mine, Ngini
	2nd ,,	Thou, Ngunnungo	Thine, Nguni
	3rd ,,	He, Nha-ungo	His, Dinnin

Dual.

1st Person	We, incl., Ngalngingo	Ours, incl., Ngalungun
	We, excl., Ngullungo	Ours, excl., Ngullan
2nd ,,	You, Bullungo	Yours, Bullan
3rd ,,	They, Ngamulngo	Theirs, Damalinya

Plural.

1st Person	We, incl., Ngūndingo	Ours, incl., Nguandan
	We, excl., Ngannango	Ours, excl., Ngannan
2nd ,,	You, Nhoorango	Yours, Nhuran
3rd ,,	They, Ngamungo	Theirs, Ngamunyin

The third personal pronoun has various forms, and is often used as an ordinary demonstrative. There are pronouns meaning "me," "myself," "towards me," "from me," etc., the same as illustrated by me in dealing with other languages. There are also causative forms of the nominative pronouns which must be passed over for want of space.

Interrogatives.—Ngani, who (singular). Nganibula, who (dual)? Nganinhura, who (plural)? Nganinguddha, who for? Nganinnat, who from? Nganinarak, who with? Minnhē, what? Minnhetgudda, what for? Minnhalda, what with?

Demonstratives are used in great number and variety, exhibiting niceties of expression in regard to the location of the person or thing spoken of. These demonstratives include the different points of the compass.

VERBS.

Verbs have the same numbers, persons, tenses and moods as those of the Thurrawal language,[1] and although the

[1] "The Thurrawal Gundungurra and Dharruk Languages," Journ. Royal Soc., N. S. Wales, Vol. xxxv., pp. 127 - 160.

suffixed particles differ, they are applied in a similar manner, as represented in the following conjugation of the verb mullin, to beat:

Indicative Mood—Present Tense.

Singular	1st Person	I beat,	Mullinnga
	2nd ,,	Thou beatest,	Mullinnginna
	3rd ,,	He beats,	Mullinda
Dual	1st Person	We, incl., beat,	Mullinngalngin
		We, excl., beat,	Mullinngulla
	2nd ,,	You beat,	Mullinbullak
	3rd ,,	They beat,	Mullindamulu
Plural	1st Person	We, incl., beat,	Mullinyuandak
		We, excl., beat,	Mullinyanak
	2nd ,,	You beat,	Mullinhurak
	3rd ,,	They beat,	Mullindamnak

One example each in the past and future tenses will be sufficient:—

Past Tense.

Singular 1st Person I beat, Mullēnnga

Future Tense.

Singular 1st Person, I will beat, Mulliaknga

Imperative Mood.

Beat, Mullēl. Beat not, Kuddhagana mullēl

Condition Mood.

Perhaps I will beat, Yōtadyin mulliaknga.

Reflexive.

I am beating myself, Mullinnganyen.

Reciprocal.

We (dual) are beating each other, Mullēdhanngulla
We (plural) ,, ,, ,, Mullēdhanyanak

ADVERBS.

No, yota. Yes, ngōwi. Today, kannanngur. Tomorrow, barpirrik. Day after tomorrow, yiyirrak-kanangar. Now, yimmalang. By and bye, dyinyanguna. Long ago, pappura-

bunnarak. I don't know, ngai. Perhaps, yotadyin. Where waga? Where abouts, wannhul? Whither, wannhalmuty? Whence, wŭnyin? How, wannhalum? When, wummir? There, nhullai; there, farther, dungubbera; there, farther still, ngungabunnarak. Yonder, dhumnala.

Numerals.

One, iāwa. Two, bŭltyobal.

See the vocabulary of Yota-yota words at the end of this article.

9—The Bureba Language.

This native tongue is spoken on both sides of the Murray River, from Swan Hill upwards till met by the Wamba-wamba, Giāni-giāni, Yabula-yabula and Yota-yota. Below Swan Hill, and extending right down the Murray to Wentworth, are several small tribes, such as the Watti-watti, Lātyu-lātyu, Muti-muti, Nyerri-nyerri, Darti-darti, and some others. Towards the north-east these tribes are met by the Birraba-birraba and Itha-itha communities, whose languages have been described by me elsewhere. All these triblets speak dialects having the same constitution as the Burēba, bearing also strong affinities to the Tyattyalla, but they differ more or less among themselves in vocabulary. Considerations of space will preclude more than a cursory outline of the chief elements of the language. The social organisation and "man-making" ceremonies of all the above mentioned tribes are described by me in an article to this Society in 1898.[1]

Nouns.

The number and gender of nouns are on the same principle as those of the Tyattyalla.[2] Although the dual is generally

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[1] "The Group Divisions or Initiation Ceremonies of the Barkunjee Tribes," Journ. Roy. Soc. N.S. Wales, Vol. xxxii., pp. 240 – 250 with map.
[2] "The Aboriginal Languages of Victoria," Journ. Roy. Soc. N.S. Wales Vol. xxxvi., pp. 71 – 106.

used, a trial is often met with in some of the languages mentioned in the above paragraph.

Case.—The nominative and accusative are not declined, as wan, a boomerang; laiur, a woman.

Causative.—Laiuru bupu dhaka, a woman a child beat.

Every object over which ownership can be claimed is subject to inflexion for number and person:—

Singular	1st Person	My boomerang,	Wanak
	2nd ,,	Thy ,,	Wanin
	3rd ,,	His ,,	Wanuk
Dual, 1st Per.		Our, incl., boomerang,	Wanal
		Our, excl., ,,	Wanallung
Plural, 1st Per.		Our, incl., boomerang,	Wanangura
		Our, excl., ,,	Wanangandang

There are also case-endings for the instrumental, dative and ablative.

ADJECTIVES.

Adjectives follow the qualified noun, and take the same declensions. They are compared like the Gundungurra.[1]

PRONOUNS.

Pronouns are inflected for number, person and case, and contain two forms in the first person of the dual and plural. The following examples of the nominative and possessive cases, in the singular number, will be sufficient to exhibit their inflexion:

Singular	1st Person	I, Yetti	Mine, Yettiuk
	2nd ,,	Thou, Nginda	Thine, Ngindeuk
	3rd ,,	He, Malu	His, Malgung

Who, winyar? What, nganyu? This, ginya. That, malu. The demonstratives are numerous, and of various forms, frequently taking the place of pronouns of the third person in all the numbers. This accounts for the great

[1] See my "Gundungurra Language," Proc. Amer. Philos. Soc., Phila., U.S.A., Vol. XL., pp. 140–148.

diversity of the third personal pronouns, which have little or no etymological connection with the others.

VERBS.

Verbs have the same numbers, persons, tenses and moods, as the other languages treated in this article. In the first person of the dual and plural there is a variation in the suffix of the verb indicating the inclusion or exclusion of the person spoken to. An example of the present tense of the indicative mood only will be given.

Singular	1st Person	I sit,	Ngangan
	2nd ,,	Thou sittest,	Ngangar
	3rd ,,	He sits,	Nganga
Dual	1st Person	We, incl., sit,	Ngangangul
		We, excl., sit,	Ngangangullung
	2nd ,,	You sit,	Ngangangula
	3rd ,,	They sit,	Ngangabullang
Plural	1st Person	We, incl., sit,	Ngangangur
		We, excl., sit,	Ngangandhang
	2nd ,,	You sit,	Ngangangutа
	3rd ,,	They sit,	Ngangandhana

ADVERBS.

No, bureba. Yes, ngungui. Here, gingga. There, nyua. Where, windyella.

PREPOSITIONS.

Prepositions may be either separate words, or they may consist of modifications of other parts of speech to express a prepositional meaning. Several prepositions are subject to inflexion for person and number:

Singular	1st Person	At my back,	Warmadhak
	2nd ,,	At thy back,	Warmadhangin
	3rd ,,	At his back,	Warmadhanyuk
Dual 1st Per.		At our, incl., back,	Warmadhangul
		At our, excl., back,	Warmadhangullung
Plural 1st Per.		At our, incl., back,	Warmadhangurra
		At our, excl., back,	Warmadhangandak

Numerals.

One, yuaia. Two, bullē.

Conclusion.

In the foregoing pages I have endeavoured to record and preserve the elements of nine aboriginal languages and dialects, all of which are now published for the first time. Only those who are acquainted with the difficulties attendant upon the collection of information from uncultivated races can understand the labour and time and patience which have been expended in gathering the materials for the preparation of this article.

It is perhaps too much to expect that the details of so many languages, and the materials of three vocabularies, should be free from omissions and mistakes, especially when we remember that the seat of investigation comprises about three-quarters of New South Wales, the northern frontier of Victoria, and an extensive region in southern Queensland.

The whole of this work has been done by myself, without the assistance of any person, either in collecting the particulars, or in arranging the grammars. It is hoped that these efforts may prove at least of some value as bases of future operations, and render the further study of Australian languages comparatively easy. Should this end be achieved, the labour and outlay of the author will be abundantly rewarded.

Vocabulary of Kurnu Words.

The followiug vocabulary, containing about 220 of the most important Kūrnū words in general use, has been prepared from notes taken by me from the mouths of old men and women in the native camps.

English.	Kurnu.
The Family.	
A man,	wimbadya
Married man,	burrakulli
Small boy,	kŭtyungga
Youth,	wilyarrungga
Novitiate,	kulta
Initiated man,	mŭnkamura
Father,	ngambadya
Elder brother,	kukkudya
Younger ,,	bulludya
A woman,	burraka
Married woman,	yupparilla
Young girl,	karnkali
Marriageable girl,	kumbulla
Child (neuter),	mundhanggura
Mother,	ngamugga
Mother-in-law,	gulirri
Elder sister,	kunnittya
Younger sister,	wŭrtuka
The Human Body.	
Head,	milpirri
Forehead,	pikku
Hair of head,	bulki
Beard,	wukkubulki
Eye,	mainmurra
Nose,	mindyumulu
Neck (throat),	bunba
Ear,	yuri or munga
Mouth,	yulka
Lips,	mimnai
Teeth,	ngundi
Breast (female)	ngumma
Navel,	wirngu
Belly,	mŭnda

English.	Kurnu.
Tongue,	dhurlunya
Chin,	wukka
Back,	dhurnu
Arm,	wŭnye
Hand,	murra
Thigh,	mungga
Calf of leg,	thiltya
Knee,	dhinggi
Foot,	millinya
Blood,	muppurla
Fat,	korai
Bone,	birna
Penis,	wira
Erection,	wandhadya
Testicles,	mulu
Vulva,	bŭlli
Nymphæ,	dhillin
Hair on pudendæ,	murtubulki
Copulation,	baingullana
Masturbation,	burtaburtamŭntha
Semen,	burdiñ
Urine,	kippurra
Excrement,	kilkua
Venereal,	mikkali
Inanimate Nature.	
Sun,	putyi
Heat of sun,	windhura
Moon,	dhintyanni
Stars,	buli or ngunyaga
Pleiades,	gumbalpirri
Thunder,	butangutthu
Lightning,	birnde
Chain lightning,	nimuddheri
Rain,	ngunburu

ENGLISH.	KURNU.
Fog,	kukuma
Frost,	yillingurra
Hail,	būntara
Fresh water,	thilburu
Ground,	mundi
A stone,	yunda
Sand,	gurrinya
Light (of day),	bañbukka
Darkness,	ngaımutabuttyi
Heat,	wunyuru
Coldness,	bundinyulla
Rainbow,	kurindherri
Moonlight,	boityoa
Shadow,	guindyirri
Camp,	mulye
Grass hut,	muthuguli
Bough hut,	dhurtuguli
Bark hut,	guippurra
Smoke,	dhōaro
Food (flesh),	wūnga
Day,	kalkirri
Night,	marka
Morning,	dhungkonka
Evening,	warragalka
Hill,	mukku
Sandhill,	dhunna
Grass,	muthu
Leaves of trees,	girra
Birds' nest,	wanginya
Egg,	bŭrti
Honey,	bumbulu
Path,	yutheru
Shadow of tree,	gōilburra
Tail of animal,	gurni

ENGLISH.	KURNU.
Mammals.	
Native cat, blk. and white	būnduli
Native cat, yel. and white	kĭkunya
Rock-wallaby,	wangulu
Flying-squirrel,	dhillipuru

[See mammals under "Mystic Language."]

ENGLISH.	KURNU.
Birds.	
Laughing-jackass,	gurrugaga
Native-companion,	burālga
Pelican,	wirrianungkura
Peewee,	baiindhal
Plover,	rittha-rittha
Swan,	yungguli
Crane,	baraga
White cockatoo,	gullibuga

[Other birds are given under "Mystic Language," *supra.*]

ENGLISH.	KURNU.
Fishes.	
Perch,	gūnbali
Cod,	dhuburu
Catfish,	bundali
Silverfish,	binnabuga
Black bream,	bunngulla
Reptiles.	
Bubbur snake,	bundindyura
Brown snake,	dhinga

See "Mystic Language," *supra.*

ENGLISH.	KURNU.
Invertebrates.	
Locust,	wurtu
Blow-fly,	winguru
Louse,	ngutu

English.	Kurnu.	English.	Kurnu.
Nit of louse,	butti	Afraid,	nguyalangaba
Centipede,	gilga	Right,	gundyalka
Mosquito,	ngŭndhi	Wrong,	dhulugalla
Scorpion,	dhunga	Tired,	binnamundhulla
	Weapons.	Fat,	gen-nga
Tomahawk,	wukkaga	Lean,	nindadya
Koolamin,	dhinye	Cold,	bundinyulla
Yamstick,	kunga	Angry,	burnbamurka
Spear, wood,	gabaga	Sleepy,	gunhulla
Spear-lever,	wommer	Glad,	gilpuri
Spear shield,	baiawulli	Greedy,	buri
Waddy shield,	gunba	Sick,	gullulla
Club, fighting,	birra	Stinking,	buka-buka
Club, hunting	dhuttu-birra	Pregnant,	mundabuka
Boomerang,	gattheri, wanna		*Verbs.*
Small club,	bŭngŭrdu	Die,	bukamulla
	Adjectives.	Eat,	gaila
Alive,	gilla-bukamulla	Drink,	dhundyali
Dead,	bukada	Sleep,	imagala
Large,	wurtu	Stand,	dhurri
Small,	kutthalaga	Sit,	ngingga
Tall,	baluru	Talk,	gulpa
Low,	mukadya	Tell,	gulperri
Good,	gundyalga	Walk,	gani
Bad,	dhulugalla	Run,	gulyera
Red,	ngalgirga	Bring,	gandi
White,	butha	Take,	wurragandi
Black,	kukindi	Make,	dindala
Full,	nguppalangadu	Break,	yaka
Quick,	gira-gira	Strike,	burta, bulka
Slow,	bolanyi	Fight,	muyalla
Blind,	mainmurra	Wound,	mirlpa
Deaf,	urimuko	Arise,	dhingeri
Strong,	muttyerra	Fall down,	nganggala

English.	Kurnu.	English.	Kurnu.
Look,	bummila	Shine,	bainburti
Hear,	dhŭrli	Suck,	dyungdyalla
Give,	nguga	Swim,	iga
Sing,	bukkinyulla	Search for,	wagari
Weep,	ngira	Spit,	tupala
Cook,	nguala	Smell,	para
Steal,	mirndala	Throw,	ngarta
Request,	ngandyerri	Roast,	ngoala
Blow with breath,	bupa	Whistle,	gwilpi
Climb,	binnari	Pretend,	burlinya
Conceal,	wirnki	Kiss,	murmundya
Jump,	benburri	Vomit,	mundulla
Laugh,	ginda	Dance,	bukka
Scratch,	mirra	Dive,	nguppoagalla
Send,	karndi	Sting,	bŭnda

Vocabulary of Yualeai and Yota-yota Words.

The following vocabulary contains about 365 English words with their equivalents in the Yualeai and Yota-yota languages, thus making a total of 730 native terms. Every word has been carefully written down by myself from the lips of the native speakers.

English.	Yualeai.	Yota-yota.
A man	urē	yiyir
A husband	gulire	winyanbunayir
Old man	thunningurri	dhamiyirr
Very old man		dyirribung
Clever man	wiringin	ngaraga
Small boy	birradyul	mulnigaptya
Youth, before initiation		malnēga
Youth, partly initiated		wōnga
Youth, after extraction of tooth		gogamulga
Youth, fully initiated		dyibbauga
Elder brother	dhaia	pānyupa

English.	Yualeai.	Yota-yota.
Younger brother	kullaminga	pānyip
Elder sister	bōadhi	dhaigip
Younger sister	boannga	pugika
A woman	inar	winyar
Old woman	mamigulla	dhamawinyar
Woman during menses		kartubulla
Wife	gulir	winyar
Small girl	meadyul	nyauwoga
Young woman		dhuddiwa
Time of first menses		durguggimuty
Maid at first menses		maia
Father	boadyir	nhungui
Mother	gunidyir	nhannha
Child of either sex	birralidyul	guthūpka

The Human Body.

Head	dhaigal	boko
Forehead	ngulu	ngunyer
Hair of head	bullundhur	bukan
Beard	yerri	moandhiuring
Eye	mil	mē
Nose	muyu	kauwu
Back of neck		wunnawurra
Throat	wuyu	dyia
Ear	udha	marmu
Mouth	ngaih	kutta
Lips	illi	wuru
Teeth	ia	dirrŭn
Breast, female	ngummo	baiyi
Navel	wirrigal	kagadha
Afterbirth	ngalir	nyittāwa
Belly		bulli
Back	baua	bunnūth
Arm	būngun	bōrnu
Elbow	ngunuga	ngunangga

English.	Yualeai.	Yota-yota.
Shoulder		kuttir
Hand	ma	tyirtyirran
Thumb		nhana
Thigh	mubbun	ngurgatyirrimna
Knee	dhinbir	yukun
Foot	bubbur	tyunna
Heart		ngŭngwura
Liver		bōrtha
Blood	gō-oi	māwa
Fat	wammo	wallaktya
Bone	buia	lilluma
Penis	dhūn	nukkin
Erection	gilwurri	taiu
Testicles	buru	budyanga
Hair on pudendæ	buthe	yimiñ
Sexual desire	nginngin	dyillu
Copulation	thadha	dhanin
Masturbation	kaiaiabilla	dyilluñ
Sodomy	nididharri	dhanadhan
Noise made in copulating,	kutthabul	dhungo-dhungo
Semen	barri	bulla
Emission	burrabunda	dyityin
Vulva	yangal	bunuñ
Nymphæ	binnunggal	
Anus		muttya
Excrement	guna	gunē
Urine	kil	gumuñ
Venereal	babadi	bēwa

Inanimate Natural Objects.

Sun	yiai	yōrnga
Moon	bālu	yora
Stars	goburrai	tutuñ
Orion's belt	birri-birrai	
Pleiades	mēmēai	

English.	Yualeai.	Yota-yota
Sky		yuradha
Sunshine		dhuddyauar
Thunder	dhulumai	munnara
Lightning	dhungēra	tyirngawan
Rain	iu	gōrgurra
Rainbow	yaluwiri	
Dew	gugil	yăwa
Fog	gua	yanggāwa
Frost	dhundhar	yūngaba
Hail	dhaian	nyinnuga
Water	gungun	walla
Dirty-water		muppagoa
Ground	dhemar	wukka
Mud	biddyai	muppun
Stone	maiama	būnga
Sand	gumbogan	watyaga
Light	dhuiai	yinya
Darkness	būllui	dhulla
Heat	bulēr	nataty
Cold	bullia	bolkaty
Camp	garema	manmun
Bark hut	dhadhar	manung
Grass hut	ngunna	
West-wind	giger-giger	
Whirlwind	buli	
Dust storm	maira	
Mirage	yerradher	
Pipe-clay		tarnga
Red ochre		putthōga
Fire	dhu	pitya
Smoke	wuyugil	thóanga
Food, meat	bunna	mūllan
Food, vegetable	dhuar	
Thirst		thanga

English.	Yualeai.	Yota-yota.
Day	yiaí	kananngur
Night	bulwi	thalla
Morning	gibābu	yawa
Evening	bulului	yēlbuga
A splinter	muyandhuduñ	malnha
Hill	dhuyul	
Sandhill	gumbogandul	wammudyamulloga
Grass	bunu	bŭrpa
Leaves of trees	garil	dawaru
Bird's nest	gareme	manung
Eggs	gō	budyanga
Honey	warrungunna	
A tell-tale	dhubanmulligu	
Grub in box tree		mērin
Grub in gum tree		balaga
Grub in ground		kuka
Bloom on trees		bōwurring
Pathway	yúruwundul'	dana
Shadow of tree	dhuddin	mulāwa
Shadow of man	mulluwil	
Tail of animal	dhun	nukkin
Summer	yaiba	
Winter	dhundarba	

Animals—Mammals.

Native bear	guda	gŭrbur
Dog	madhai	bukka
Opossum	mudē	buttya
Kangaroo-rat	gunhar	ngurnuada
Native cat, black and white	buggundi	miya
Native cat, yellow and white		burraty-ba
Bandicoot	guyu	thalwa
Small kangaroo-rat	bilba	
Water-rat	gumai	

English.	Yualeai.	Yota-yota.
Porcupine	biggibilla	
Kangaroo	baura	burra
Platypus		wannagapippua
Flying-squirrel		birranga
Ringtail opossum		bindyarama

Animals—Birds.

Birds collectively	dhiggaia	tyōanda
Crow	wān	dŭngami
Laughing jackass	gugurgāga	dūrdyulapka
Curlew	u-i-an	billuoba
Mallee-hen	waggūn	laua
Plain turkey	gumbulgubbin	māndya
Native companion	buralga	kunugudula
Pelican	gulambula	dhaiilipnha
Swan	baiamal	turnupnha
Woodduck		kunyugoa
Bat	ngarrādhan	mumianga
Quail		bōrkir
Eaglehawk	mullean	wānmirr
Emu	dinnawan	biggarumdya
Common magpie	buragalbu	korngañ
Black magpie		bēnia
Black duck	budhanba	dōlma
Mopoke		kōkōk
Bronze-wing pigeon		mūngoburra
Lark		dhuddadudda
Rosella parrot		dudūtya
Parrokeet		dēkula
Common hawk		pittyinna
Kingfisher		nurnamamdatba
Peewee	burrindyin	tyilloanga
Plover	baldhurradhurra	timmulbornya
Crane	gurrāga	kalmuka
White cockatoo	muyai	tyarring

English.	Yualeai.	Yota-yota.
Black cockatoo		nyanang
Weejuggler	guggilariñ	
Fish-hawk	wulla	
Heron	durrūn	
Galah	gillā	
Bowerbird	wida	
	Animals—Fishes.	
Perch		kungupgah
Cod	gudu	būrmanga
Catfish	gaigai	
Frog	yuaya	dhungoba
Silverfish	birnga	
Yellow-belly	dhuggai	
Bream	bunngulla	wūrthumurra
Trout		bungame
	Animals—Reptiles.	
Ground iguana	biwi	baryebala
Tree iguana	mungungāli	biltyimdya
Sleepy lizard	ubun	
Small lizard	gudda	bombala
Shingleback	kurbali	mutirr
Death adder	murubi	
Carpet snake	yubba	mamell
Brown snake	ngundhaba	
Black snake	wuyubului	minguriny a
Tiger snake	bubbur	
Jew lizard		woala
Wood lizard	wallubāl	
	Animals—Invertebrates.	
Locust	ngurrulla	dẏunna
Blow fly	gummu-gummu	dyēndyura
Louse	muni	muna
Mother-louse	gubbul	
Nit of louse	gaiai	timmin

English.	Yualeai.	Yota-yota.
Bull-dog ant	buyugu	gudyidya
Centipede	gian	thŭltin-gin
Jumper ant	milbawai	
Maggot		tutula
Common house fly	muguñ	wāwunya
Grasshopper	bunbun	yunādya
Spider	murgamurgai	
Mosquito	mūng-in	bētha
Scorpion	guna	tilla
Greenhead ant	baiar	bumanebula
Mussel	munggi	diddling-er

Trees and Plants.

Any leaning tree	bundhirri	kandyima
Any dead tree	burngiñ	dauwir
A hollow tree		durdabulla
Any large tree	bungil	dyealna
Ti-tree		dyima
Willow, wild		ngŏrtya
Myall	maial	gānga
Wattle		ngummara
Pine	bailiñ	waw-lulla
Oak		barttya
Cherry-tree		bāla
Red-gum tree	guraua	dharnya
White box		baiuna
Yellow box		bēruga
Honeysuckle		bitthin
Bullrushes		maiyilla
Yam		maiyilla
Desert pea	gillunggara	
Sandalwood	buddhar	
Whitewood	būrbul	
Beefwood	mumbo	
Brigalow	kulbai	

ENGLISH.	YUALEAI.	YOTA-YOTA.
	Weapons, Utensils, etc.	
Tomahawk	kumbō	dŭtyimba
Koolamin, wood	binggui	
Koolamin, bark	welbun	
Koolamin, for honey	wirri	
Yamstick	dhibai	nŭnyer
Spear, wood	billar	dyikura
Spear, reed		kama
Fishing spear		wunnaga
Spear lever	wommurra	yōlwa
Spear shield	burin	bornyir
Waddy shield		mŭlka
Fighting club	bugu	burrunggala
Hunting club	murula	bān-ga
Boomerang	burran	wŭnya
Net bag		murra
Canoe		muttha
Large bag		kunki
Paddle		kagadya
Headband		murrungngulling
Belt		kunnedhula
Kilt		ngōreh
	Adjectives.	
Alive	mūrrun	dhoana
Dead	ballune	kokuñ
Large	burul	dunngidya
Small	bŭdyen	ying-arna
Tall or long	guyar	dyurrungunna
Low or short	buyadyul	thuluka
Good	kubba	kalinya
Bad	guggil	mutthē
Thirsty	bullal	thang-um
Red	kwainburra	moamaty
White	bullā	pet-tyaity

English.	Yualeai.	Yota-yota.
Mad or crazy	womba	
Black	bului	dhullanun
Full	ngaibo	wurumaty
Quick	burrai	yunyuwula
Slow	bullua	thurramdyuba
Blind	muga	moadhaty
Deaf	wumba	nhubbada-marma
Strong	wullanba	dunngolōdya
Afraid	giel	dyiuman
Right	maiu	kalnirrin
Wrong	walmaiu	muddhindhŭn
Tired	inggil	murralatyamaty
Blunt, edge	mugur	manha
Blunt, point		nhurupka
Sharp edge or point		buggadhulliñ
Fat	wammo	walitya
Lean	bilga	walibulla
Hot	dhubiai	
Cold	bullia	boalkuty
Angry	ile	koalyunan
Sleepy	yuar	ngulyēn
Glad	kubbayul	wullanhan-bukkaba
Sorry	kuggilyul	dunngalaty-dyumity
Greedy	dhurin	dyirnyaua
Sick	dhālane	ittyumuty
Stinking	nhui	didyumura
Baldheaded	wuggiba	gulnyaoga
Prĕgnant	yuleai	bullēana

Verbs.

Die	ballugigu	kukuñ
Eat	dhulligu	dutyim
Drink	ngaugigu	dhangun
Sleep	dunduigu	nunnha
Stand	wurrai	dana

English.	Yualeai.	Yota-yota.
Sit	illawai	ġarwul
Talk	gwalligu	loatbaty
Tell	dhubanmulla	ngariaty
Walk	nhawanna	yarwul
Run	bunnagaigu	yumma
Bring	dhaigang-a	yukkorma
Take	gang-a	mumma
Make	gimbilli	buñma
Break	gummulligu	kunga
Strike	bumulligu	nyinna
Beat	bumulligu	mullin
Wound	gurrilligu	kuthana
Arise	wurraia	kumbinna
Fall down	bundang-a	tātēn
See	ngurrilla	nhanha
Look		nhawul
Hear	winnunggulla	ngarnhung
Listen		ngarwul
Give	wuna	ngunu
Sing	bauilla	bā-i-ya
Weep	yugi	dūnhu
Cook	illamulligu	thurra
Steal	munnamulligu	biddhanda
Request	dhaialli	minnamda
Blow with breath	bubilli	boama
Climb	gulliē	wurwaty
Conceal	dhurimbulli	nhūrka
Jump	baia	yarkabuk
Jump over	bane	
Laugh	gindamaia	kārebak
Scratch	moangilli	yerka
Scratch with claw	nimmulli	
Forget	ūdhummur	nhubbadamarm
Stare at	bunbun-ngurrilla	nhattyillim

ENGLISH.	YUALEAI.	YOTA-YOTA.
Send	ūrmulla	wōtyan
Shine	wialdhunna	walwu nmuty
Suck as a child	ngummugi	bama
Suck a wound		nota
Swim	gubigu	yarwa
Bathe		maryibŭk
Search for	ngawillunna	yamuty
Spit	dhulan	thupen
Smell	ngauia	ming-a
Throw forcibly	gaiawi	munna
Pitch	wunnunga	yung-a
Roast	dhomulli	thurra
Whistle	wile	lēta
Pretend	wage	ngungeandha
Kiss	ngaigale	thumē
Vomit	gawiligu	yakalum
Dance	yorme	kurradhan
Corroboree		tumman'muty
Dive	ung-ai	durtya
Sting	dhuni	
Hunt on ground		mumulwa
Hunt in trees		wawallu
Go	naia	
Come	dhainaia	
Burn	gailamurra	
Bite	kutthera	yinnin

POT EXPERIMENTS TO DETERMINE THE LIMITS OF ENDURANCE OF DIFFERENT FARM-CROPS FOR CERTAIN INJURIOUS SUBSTANCES.

By F. B. GUTHRIE, F.I.C., F.C.S., and R. HELMS.

[Read before the Royal Society of N. S. Wales, October 8, 1902.]

Part I.—WHEAT.

THE following experiments were carried out in order to test the effect upon the growth of the wheat-plant of a few of the chemical substances occasionally present in the soil and in manures, and which are known when present in excessive quantities to seriously interfere with the growth and development of the plant.

The experiments were carried out in cylindrical culture pots of galvanized iron, 8 inches high and 8 inches in diameter. The pots were watered from below by means of an external tube, communicating with a channel in the bottom of the pot, a quantity of cinders and broken earthenware being first introduced to ensure thorough aeration and drainage. The pots were filled with the soil chosen for the experiment, each pot containing about 18 ℔s of the soil. Through the kindness of Mr. Maiden, a space was set apart in the Botanic Gardens in the open air, so arranged that a tarpaulin could be at once unrolled to cover the whole experiment in the event of heavy rain or wind. All the pots were exposed to exactly the same conditions as to light, warmth, water, etc., throughout the course of the experiment. Check-pots were also filled, sown, and treated in exactly the same way for purposes of comparison, omitting the substances whose action was being studied.

Nature of the Soil.—Two kinds of soil were used. That with which the pots were originally filled, and in which

grain was sown on June 3rd, was a mixture of about one part of a light sand, one part of clay, and two parts of loam. Each pot received in addition the following fertilising mixture:—15 grms. sulphate of ammonia; 6 grms. superphosphate; 4 grms. sulphate of potash; together with varying quantities of the substances whose action was under investigation.

The composition of this soil was as follows:—

Moisture	... ...	3·83	
Organic matter	...	13·75	
Nitrogen	... ...	·208	
Soluble in strong HCl.			
Lime	... ...	·165	per cent.
Potash	... ...	·065	,,
Phosphoric acid	...	·107	,,
Magnesia	... ...	·072	,,

The soil was found to contain in addition ·016 per cent. sodium chloride, so that the percentages of common salt in the pots devoted to experiments to test the action of this substance must be increased by this amount. On this account the pots that were resown on subsequent dates were filled with soil No. 2 which was one in which potatoes had been growing.

The composition of soil No. 2 was as follows:—

Moisture	... ...	2·91
Organic matter	...	8·33
Nitrogen	... ...	·070
Soluble in strong HCl.		
Lime	... ...	·440
Potash	... ...	·077
Phosphoric acid	...	·110

This soil was free from chlorides and did not receive any manure.

Experiments with Common Salt.

Five pots were filled with soil No. 1 together with the complete fertiliser and the following quantities of sodium chloride, per 100 lbs of soil :—

No. of pot	15,	·01	per cent.	NaCl.
,,	16,	·05	,,	,,
,,	17,	·10	,,	,,
,,	18,	·50	,,	,,
,,	19,	1·00	,,	,,

As it was found afterwards on analysis of this soil that it contained ·016 per cent. NaCl, the above figures become ·026, ·066, 116, ·516, and 1·016 respectively.

The pots were sown on June 3rd with 10 grains of wheat in each pot. A light mulch of shredded cocoa-nut fibre was placed in each pot and the earth kept slightly moist throughout the experiment.

On July 1st notes were taken as to the appearance of the different pots.

15, had germinated well, growing vigorously. (The grain is now in the ear, Oct. 8th.)

16, had germinated well, growing well but not as vigorously as No. 15.

17, had germinated well, growing less vigorously than No. 15.

18, had not germinated.

19, had not germinated.

Pots No. 16, 17, 18, and 19 were thrown out and resown on July 3rd. Soil No. 2 free from chlorides, being used and no fertiliser added. They received sodium chloride as follows :—

No.	16,	·02	per cent.	NaCl
,,	17,	·05		,,
,,	18,	·10		,,
,,	19,	·20		,,

Notes were made of the appearance of these pots on July 24th, and again on August 26th.

No. 16 had germinated well and growing well (heads are forming, Oct. 8th.)

No. 17, germination slightly retarded, but recovered and was growing well.

No. 18, germination considerably affected, poor in appearance (July 24th) but recovered and growing well (Aug. 26th).

No. 19, germination much affected, growth very feeble. Plants dead August 26th.

A further set of pots was resown on July 28th with the following quantities of salt:—

Pot No.	24,	·10	per cent. NaCl
,,	27,	·15	,,
,,	30,	·20	,,
,,	31,	·30	,,

On August 26th these pots presented the following appearance:—

24, germination retarded.
27, germination more retarded.
30, germination very feeble.
31, very few germinated.

From the above experiments the following summary of conclusions is drawn:—·01 to ·02 per cent. NaCl is without effect upon the wheat plant, the grain germinating well, and the plants growing vigorously. With ·05 to ·10 per cent. NaCl the germination is somewhat retarded, the plants are less vigorous but recover and grow well. With ·15 the germination is still more affected and the plants would probably not recover under less favourable conditions than those of the experiment. ·20 per cent. NaCl in the soil is fatal to the growth of wheat.

Experiments with sodium carbonate.

Sodium carbonate is present in the water of many of the artesian bores in New South Wales. As these waters constitute in many cases the only available supply for irrigating, the question of the limit of tolerance of different crops for this alkali is one of considerable importance. When water charged with alkali is used for irrigating, the soil frequently becomes covered with a white crust consisting of sodium carbonate. This is due to capillary action which brings the alkali to the surface where it is left as a deposit on evaporation of the water. When the amount of alkali present is considerable, the soil becomes quite hard, and tillage operations are rendered very difficult and in some cases impossible. These conditions were not reproduced in the experiments, the surface of the pots being covered by a mulch, so that surface evaporation was reduced to a minimum, the soil was always moist, and the drainage effectively prevented the accumulation of water or of water charged with alkali. The experiments therefore represent the action of the akali upon the plant itself, without reference to its possible deleterious effects upon the soil.

Pots were filled with soil No. 1, and fertilised and sown on June 3rd in the manner already described. The following pots were prepared :—

Pot	21,	·01	per cent Na_2Co_3
,,	22,	·05	,,
,,	23,	·10	,,
,,	24,	·50	,,
,,	25,	1·00	,,
,,	26,	3·00	,,

On July 1st, the appearance of these pots was as follows:

Nos. 21 and 22 had germinated well, growing well, (grain in the ear, Oct. 8th.)

No. 23 had germinated well, not quite so vigorous, backward, (grain not forming Oct. 8th.)

No. 24 germination weak, plants very puny, had died by July 24th.

Nos. 25 and 26 did not germinate.

Pots 25 and 26 were resown in No. 2 soil on July 3rd with ·2 and ·4 per cent. Na_2Co_3 respectively.

In pot 25, containing ·2 per cent. Na_2Co_3, the seeds germinated well and the plants were growing well on July 24th and August 26th, the heads were forming Oct. 8th. In the pot containing ·4 per cent. Na_2Co_3 germination was much affected, and the plants were very feeble on July 24th and had all died by August 26th. In the other pot containing ·30% Na_2Co_3 germination had been retarded and the plants were less vigorous on August 26th.

The conclusions drawn are the following:—Quantities of Na_2Co_3 up to ·20 per cent. of the soil do not affect the growth of wheat in any way. With ·30 per cent. Na_2Co_3 in the soil germination is affected, with ·40 per cent. the germination is much affected and the plants die. ·3 per cent. can therefore be regarded as the limit of endurance.

Experiments with ammonium sulphocyanide.

Ammonium sulphocyanide is occasionally present in sulphate of ammonia, particularly in the product obtained from the commercial liquor of the gas-works. We have never come across it in any samples of sulphate of ammonia manufactured locally, but its poisonous action is so much greater than that of the substances just discussed, that it appeared a matter of some importance to ascertain how much plants can stand.

The following pots were prepared and filled with soil No. 1 and manured and sown as before on June 3rd.

Pot	28,	0·01 per cent.	NH_4CNS
,,	29,	0·05	,,
,,	30,	0·10	,,
,,	31,	0·50	,,

None of the above germinated, and the pots were resown on July 3rd with soil No. 2 (no manure added).

Pot	28,	·001	per cent. NH_4CNS
,,	29,	·003	,,
,,	30,	·005	,,
,,	31,	·01	,,

On July 24th, Pot No. 28 had germinated well, but growth was retarded, the plants were poor in colour and the tips of the leaves were becoming yellow.

Pot 29 had germinated but the plants were growing very feebly.

Pot 30 had germinated, the plants were very feeble and apparently dying.

Pot 31 had hardly germinated, and the plants had died.

On August 26th—

Pot 28 had recovered, and the plants were growing fairly well.

Pot 29 had also recovered and was growing fairly.

Pot 30, all the plants were dead.

The conclusions drawn are the following :—·01 per cent. of ammoniun sulphocyanide in the soil prevents germination, quantities as small as ·001 per cent. seriously affect the growth of the plant, which however, under favourable conditions may recover. ·005 per cent. is fatal to the growth of the plant.

Experiments with sodium chlorate.

This ingredient is sometimes present in nitrate of soda. The following experiments were carried out to ascertain the proportion of this substance which the wheat plant can tolerate without being injuriously affected.

The following pots were prepared, filled with soil No. 1 and sown on June 3rd :—

Pot	32,	·01	per cent. $NaClO_3$
,,	33,	·05	,,
,,	34,	·10	,,
,,	35,	·50	,,

With the exception of 32, none of the seed in the above pots germinated. In No. 32 the seed had germinated, but the plants were very feeble and were all dead when examined on July 1st.

The pots were therefore resown on July 3rd with soil No. 2, the following quantities of sodium chlorate being added:—

Pot 32, ·001 per cent. $NaClO_3$
,, 33, ·003 ,,
,, 34, ·005 ,,
,, 35, ·01 ,,

In Pot No. 35 the seed germinated as with pot 32 in the preceding experiment, but the plants were very feeble, and by July 24th they were all dead.

Pot 34, the seed germinated but growth was feeble, and plants were dying when examined on July 24th and died subsequently, being all dead by August 26th.

Pot 33, seed germinated but plants were growing very feebly on July 24th and August 26th.

Pot 32, the seeds germinated well, the plants on July 24th were weak and slightly discoloured. By August 26th they had recovered and were growing fairly.

The conclusions drawn are the following:—Germination is not seriously affected until the amount of sodium chlorate in the soil approaches ·01 per cent., but the subsequent growth of the plant is injuriously affected by so small an amount as ·001 per cent. and the limit is exceeded at ·003 at and above which quantity the presence of sodium chlorate is fatal.

Experiments with arsenious acid.

Since the recent enquiry in England into the cause of wholesale poisoning by beer, which revealed the fact that the glucose used in brewing frequently contained arsenic traceable to the pyrites and sulphur used in the manufacture of sulphuric acid, attention has been directed towards

the possibility of this ingredient being present in other substances which are used commercially.

Amongst these must be counted fertilisers compounded of superphosphate in the preparation of which sulphuric acid is employed. If the ingredients employed in the manufacture of the acid are not free from arsenic, this substance will be present in the resulting fertiliser. It is known to have an injurious effect upon the growth of plants, and the following experiments will indicate its effect upon wheat.

The following pots were sown on June 3rd in No. 1 soil, the complete fertiliser having been added, together with varying amounts of arsenic trioxide:

Pot 37,	·01	per cent. As_2O_3
,, 38,	·05	,,
,, 39,	·10	,,
,, 40,	·50	,,
,, 41,	1·00	,,

Pot 37, germinated well, plants not affected and growing well on July 1st and 24th, and were growing well on August 26th; grain is now forming in the ear Oct. 8th.

Pot 38, germinated well, but early growth not very vigorous, plants growing fairly August 26th; grain is in the ear on October 8th.

Pot 39, germinated fairly well and plants growing fairly on July 1st, subsequent growth poor and weak. Oct. 8th grain is forming in the ear, but plants are very stunted and grain backward.

Pot 40, germination poor, plants very puny (July 1st), and almost dead by July 24th, still alive but very feeble by Aug. 26th, all dead by October 8th.

Pot 41, germination and early growth very feeble, plants nearly dead by July 24th, all dead by August 26th.

The conclusions drawn are as follows:—germination and early growth is affected by the presence of ·05 per cent.

arsenic in the soil, the injurious effect increasing as the proportion of arsenic becomes greater; with ·1 per cent. arsenic the plant does not come to maturity. The presence of ·01 per cent. arsenic is without injurious effect upon the growth of the plant.

The following table summarizes the results obtained:—

Effect upon germination and subsequent growth of the wheat plant of different percentages of injurious substances in the soil.

	Germination affected.	Germination prevented.	Growth affected.	Growth prevented.
$NaCl$	·05	·20	·05 to ·15 (recov.)	·20
Na_2CO_3	·30	·5 to 1·0	·10	·40
NH_4CNS	·005	·01	·001	·005
$NaClO_3$	above ·01	·05	·001	·003
As_2O_3	·05	above 0·5	·05	·10

Attention must be drawn to the fact that in these experiments the injurious substances were incorporated with the soil prior to planting, and that there was no accumulation of them in any one place. In actual practice the fertilisers which are liable to contain these deleterious ingredients are applied in such a way that they are concentrated in the first few inches of the surface soil. This is especially the case when the fertiliser is drilled in with the seed, in which case they are concentrated in the immediate neighbourhood of the germinating seed. For example, ·2 per cent. sodium chloride in the soil was found in the above experiments to be absolutely fatal to the growth of wheat. This amount represents about 5,000 lbs. or nearly 2¼ tons of salt distributed over an acre of soil of average weight to a depth of six inches. Such a dressing would not be applied in practice, but the same injury would result to the plant if the few pounds of soil in its immediate neighbourhood and from which it draws its food-supply were charged with salt to the same extent.

CURRENT PAPERS, No. 7.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[With Diagram.]

[*Read before the Royal Society of N. S. Wales, September 3, 1902.*]

THE number of current papers is steadily increasing year by year. The first paper which was read before this Society on October 3rd, 1894, contained 43 current papers—the accumulation that had extended over four years. No. 2 contains the current papers which had accumulated in two years, and numbered 200, of these the late Dr. Neumayer, then the Director of the Hamburg Meteorological Observatory, sent me 23, and Captain A. Simpson contributed 41, which he had himself sent out and then collected.

No. 3 pamphlet contains 167 current papers, collected in two years and one month, all of which were sent to me. During this time north-west winds were prevalent, blowing off the Australian Bight, and in this way hindered the landing of current papers in the Australian Bight, as the diagrams in No. 3 shew. This pamphlet bears out the experience from No. 2, viz., that the rate of drift south of Australia is gradually increased from Latitude 30° to 47° 16′ South. At that time 101 icebergs were reported by captains of ships on the voyage between Australia and Cape of Good Hope.

No. 4 pamphlet contains amongst other things the drift of the "*Perthshire*," and this is the first pamphlet in which the period of collecting papers is confined to twelve months. It is also noteworthy that this year 1899 the drifts in the Atlantic, the Indian Ocean, and the Southern Indian Ocean were all unusually strong.

No. 5 contains particulars of the drift of the Waikato for 103 days. The number of bottle papers amounted to 93, of which five papers thrown into the Indian Ocean, four landed in Africa, and one in Madagascar. It is very noteworthy that at this period the drift of the current papers in Southern Indian Ocean was east by south, while in other cases it is east by north. This featûre is important, as indicating some changes of meteorological conditions not otherwise observed.

No. 6 contains 153 current papers collected in one year, and in this period another ocean comes into the field traversed between Australia and Canada. Valuable as they are for navigation, they suggest the interesting question—will it be possible to find out by current papers the direction if any, by which the equatorial currents from the Pacific Ocean make their way through Torres and other Straits, through various possible openings into the Indian Ocean? There the drifts to the west are more rapid than any other place that I am aware of. It seems, therefore, most desirable to get many more current papers afloat between Sydney and Canada.

In this pamphlet, Capt. J. Mann Hart of the s.s. "*Star of New Zealand*," we have the first report of a group of icebergs for a long time. The diagram shews a great number of small icebergs and a number of large bergs in 55° south and between 130° to 144° east.

RAPID DRIFT.

It is noteworthy that amongst the current papers we find the most rapid drift that we have yet discovered: No. 858; the rate reported being 32·5 miles per day, but the period of drift was only two days. Some caution must be exercised in this drift, errors in the times given, such as often occur in watches might be enough to make this drift appear large when it was not actually so. But there are

two others, Nos. 848 and 854, which have most remarkable rates of drift—29·5 and 21·0 miles per day respectively.

It will be observed that pamphlet No. 7 records a drift in current paper No. 785 of 29·2 miles per day. It was committed to the Socotra Sea and found in the Gulf of Aden, which with one exception is the most rapid drift on record—the paper referred to is No. 21 in the first pamphlet with a rate of 31·0 miles per day. With one exception—No. 164 with a drift of 9,585 miles—the longest drift shewn in this pamphlet is No. 891 with 9,020 miles.

List of current papers arranged in months in which they were received:—

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1896	No	obse	rvat	ions			Wor	k be	gan	3	7	11	21
1897	5	7	4	5	10	7	9	9	3	8	9	6	82
1898	6	7	6	2	10	7	5	9	4	16	8	12	92
1899	11	11	11	6	13	9	10	15	7	16	11	10	130
1900	14	20	11	12	8	10	9	7	9	17	10	8	135
1901	13	13	14	11	10	13	6	9	9	14	11	15	138
1902	12	14	15	17	8	12	7	7	10	3	...	.	105
Total	61	72	61	53	59	58	46	56	42	77	56	62	703
Average	10·1	12·0	10·2	8·8	9·8	9·7	7·7	9·3	7·0	11·0	9·3	10·3	

RATE OF DRIFT IN THE WEST SIDE OF TASMAN SEA.

S.S. "*Kamona*," Union S.S. Co.

"On the trip from Tasmania to Sydney, from October 30th to the 2nd November, I experienced the strongest southerly current I ever felt along the New South Wales coast between the above dates. It is a common thing in the summer months to measure from 27 to 37 miles more than the actual distance between Cape Everard and Sydney (High Light), but on my last trip, I measured 54 miles more than the actual distance between Kent's Group (Bass' Strait) and Sydney High Light; also we were 5½ hours behind time and had fine weather all the way."

C. SUFFERN, Master.

LIST OF CURRENT PAPERS THAT MADE A RAPID DAILY DRIFT,

Taken from Current Pamphlets Nos. 1 to 7 inclusive.

No. of Pamphlet.	List number of paper.	Miles per day.	Locality of Current.
1	3	12·0	South Coast
	5	11·0	East Coast
	8	16·0	East Coast
	21	31·0	Arabia
	25	11·2	North Pacific
	41	12·0	East Coast
2	56	16·8	Indian Ocean
	64	17·7	East Coast
	102	15·4	Indian Ocean
	104	14·4	India Coast
	107	18·8	South Coast
	130	18·1	Atlantic Ocean
	148	11·7	Southern Ocean
	175	18·6	Brazil
3	210	13·5	Indian Ocean
	211	21·2	South Coast
	217	12·4	Southern Ocean
	218	14·2	Indian Ocean
	222	11·7	Indian Ocean
	233	15·3	Indian Ocean
	258	16·9	Indian Ocean
	261	28·3	West Indies
	273	11·7	Arabian Sea
	323	12·5	Indian Ocean
	329	16·0	East Coast
	353	21·3	English Channel
	355	11·5	Tasman Sea
	358	14·2	South Coast
	364	19·4	Indian Ocean
	366	14·7	Indian Ocean
4	380	13·2	South Coast
	385	11·2	Southern Ocean
	388	14·0	South Coast
	392	13·3	East Coast
	406	12·7	East Coast
	418	17·8	English Channel
	431	11·5	East Coast
	433	14·2	South Pacific
	449	14·5	Indian Ocean
	450	12·9	Southern Ocean
	452	12·2	Southern Ocean
	454	12·1	South Atlantic
	456	12·7	Indian Ocean
	466	13·3	Southern Ocean
	488	12·6	East Coast
	491	18·3	West Africa
5	514	12·9	East Coast
	529	15·6	Indian Ocean
	530	16·5	Gulf of Aden
	532	21·4	Gulf of Aden
	551	19·4	North Pacific
	559	14·6	Ceylon Coast
	561	25·4	Indian Ocean
	574	20·6	Indian Ocean
	581	16·3	East Coast
	587	18·5	Indian Ocean
6	598	11·1	North of Fiji
	625	17·1	New Caledonia
	644	16·2	Gulf of Aden
	652	11·2	Oceania
	658	11·5	Coast nr. Sydney
	668	11·6	E. of N. Caledonia
	671	19·5	Gilbert Islands
	674	16·8	Phœnix Islands
	676	17·1	Coast S. of Sydney
	681	15·5	Indian Ocean
	687	18·5	Indian Ocean
	690	12·5	S.E. Coast
	691	15·9	Indian Ocean
	702	11·0	S. Indian Ocean
	711	11·3	Indian Ocean
	727	12·7	Indian Ocean
	732	22·5	Fiji
	734	17·9	Gulf of Aden
	750	11·4	Indian Ocean
7	773	17·1	Indian Ocean
	784	12·5	Gulf of Aden
	785	29·2	Gulf of Aden
	848	29·5	South Africa
	875	13·0	Southern Ocean
	880	13·8	S. W. Coast
	907	11·0	Southern Ocean
	916	14·9	Indian Ocean

LONG DRIFTS OF CURRENT PAPERS, SELECTED FROM THE SEVEN PAMPHLETS PUBLISHED BY THE SYDNEY OBSERVATORY.	No. of paper in list.	Distance travelled in miles.	Rate per day in miles.
Current pamphlet, No. 1 (July 1883 to June 1894; 43 current papers)	2	3,300	4·0
	3	5,100	12·0
	27	3,600	9·5
	37	4,100	7·0
Current pamphlet, No. 2 (June 1894 to August 1896; 157 current papers)	180	5,905	9·2
	170	5,970	9·4
	169	4,779	9·3
	168	8,840	9·2
	157	9,517	9·0
	163	8,617	7·9
	164	9,585	10·3
	128	4 760	...
	147	4,081	9·0
	148	4,557	11·7
	158	6,375	8·6
	165	4,339	5·7
Current pamphlet No. 3 (August 1896 to November 1898; 167 current papers)	216	5,650	9·2
	215	4,800	7·8
	217	4,600	12·4
	218	4,890	14·2
	357	5,115	8·1
Current pamphlet No. 4 (November 1898 to November 1899; 124 current papers)	430	9,567	9·6
	452	9,025	12·2
	451	8,850	...
	385	4,100	11·2
	409	4,714	9·2
	410	4,550	8·5
	425	6,300	7·4
	466	6,550	13·3
Current pamphlet No 5 (November 1899 to October 1900; 106 current papers)	510	3,850	7·3
	527	5,321	4·5
	561	3,785	25·4
	574	4,400	20·6
	587	3,740	18·5
Current pamphlet No. 6 (October 1900 to November 1901; 154 current papers)	659	9,950	7·3
	702	9,850	11·0
	680	4,665	6·0
	681	4,540	15·5
	691	4,250	15·9
	708	5,610	5·2
	726	4,130	6·0
	741	4,165	7·7
Current pamphlet No. 7 (November 1901 to October 1902; 164 current papers)	755	3,900	10·9
	773	4,400	17·1
	852	4,140	8 6
	867	3,105	6·2
	868	3,185	9·2
	869	3,007	9·6
	891	9,020	9·3
	892	4,375	9·4
	907	3,355	11·0
	916	4,830	14·9

OCEAN CURRENTS.

Ref. No.	Date when put into the sea.	Name of Ship.	Name.	Thrown Over. Lat.	Thrown Over. Long.	Where Found. Lat.	Where Found. Long.	Date when Found.	Locality.	Interval Days.	Estimated Distance in Miles.	Rate per Day.	Ref. No.
				° ′	° ′	° ′	° ′						
752	Feb. 7, 1902	S.S. 'Afric'	— Alford, Commander ..	36 5 S	21 38 E.	34 35 S	20 5 E.	Mar. 21, 1902	South Africa	42	136	3·2	752
753	Oct. 7-00	,, 'Alameda'	— Van Otterendorp, Com.	4 4 ,,	167 49 W.	5 45 N	154 20 ,,	Sept. 11 01	Oceania ...	339	2698	8·0	753
754	Jan. 1-00	Barque 'Amazon'	P. H. Day, Master	40 0 ,,	119 39 E.	37 50 S.	140 20 ,,	Feb. 5-02	South Coast	765	1150	1·5	754
755	June 29-01	R.M.S 'Arcadia'	A. C. Loggin, Commander	12 25 ,,	96 53 ,,	2 30 ,,	40 50 ,,	June 22-02	Indian Ocean	358	3900	10·9	755
756	Sept. 30-01	,, ...	,, ,,	36 23 ,,	138 38 ,,	36 6 ,,	139 42 ,,	March 1-02	South Coast	152	59	0·4	756
757	Jan. 17-02	,, ...	F. C. A. Lyon, R.N.R., Com.	8 10 N	70 39 ,,	4 22 N	73 38 ,,	July 20-02	Arabian Sea	184	331	1·8	757
758	Feb. 20-02	,, ...	,, ,,	37 46 S.	149 56 ,,	33 54 S	151 17 ,,	April 6-02	South Coast	45	234	5·2	758
759	Mar. 2-02	,, ...	,, ,,	35 18 ,,	1 8 15 ,,	34 43 ,,	118 35 ,,	May 7-02	S.W. Coast ..	66	34	0·5	759
760	May 25-02	,, ...	,, ,,	35 27 ,,	137 16 ,,	35 40 ,,	136 58 ,,	June 14-02	South Coast	20	21	1·1	760
761	June 20-02	,, ...	,, ,,	35 32 ,,	135 44 ,,	38 23 ,,	141 30 ,,	Aug. 22-02	,,	63	265	4·2	761
762	Nov. 4-01	M.M.S.S. 'Armand Behic'	M. le Coispellier, ,,	35 24 ,,	124 21 ,,	33 56 ,,	124 36 ,,	Feb. 7-02	,,	95	130	1·4	762
763	July 2-97	R.M.S. 'Austral'	J. F. Anderson, ,,	30 30 ,,	110 40 ,,	30 38 ,,	115 23 ,,	Oct 15-97	West Coast...	105	282	2·7	763
764	July 25-00	S.S. 'Australasian'	— Spalding, ,,	34 58 ,,	114 22 ,,	31 43 ,,	128 57 ,,	...	S.W. Coast ..	...	880	...	764
765	Nov. 22-01	R.M.S. 'Australia'	F. Cole, ,,	35 23 ,,	124 21 ,,	33 20 ,,	124 0 ,,	Mar. 1-02	South Coast	99	119	1·2	765
766	Nov. 25-01	,, ...	,, ,,	36 34 ,,	138 56 ,,	35 34 ,,	138 39 ,,	Dec. 15-01	,,	21	57	2·7	766
767	Dec. 18-01	,, ...	,, ,,	37 53 ,,	140 11 ,,	37 53 ,,	140 20 ,,	Dec. 22-01	,,	4	9	2·3	767
768	Dec. 21-01	,, ...	,, ,,	35 40 ,,	134 22 ,,	34 0 ,,	123 10 ,,	Jan. 20-02	,,	31	140	4·5	768
769	June 8-01	R.M.S. 'Britannia' ...	F. H. Seymour, ,,	36 19 ,,	138 47 ,,	36 48 ,,	139 46 ,,	Dec. 25-01	,,	200	62	0·3	769
770	Mar. 17-02	,, ...	,, ,,	36 27 ,,	138 54 ,,	35 45 ,,	139 10 ,,	April 13-02	,,	27	43	1·6	770
771	Dec. 23-00	S.S. 'Cornwall'	R. Barter, ,,	42 31 ,,	127 45 ,,	41 55 ,,	145 8 ,,	June 1-01	South Ocean	160	890	5·6	771
772	Oct. 11-01	,, 'Eastern'	W. Ellis, ,,	35 15 ,,	150 40 ,,	34 10 ,,	151 10 ,,	Jan. 3-02	East Coast...	84	85	1·0	772
773	Mar. 27-01	'Frederick der Grosse' ...	— Eichel, ,,	15 54 ,,	99 11 ,,	21 13 ,,	35 10 ,,	Dec. 9-01	Indian Ocean	257	4400	17·1	773
774	Jan. 19-00	S.S. 'Gulf of Bothnia' ...	T. G. W. Ligertwood, ,,	35 14 ,,	125 18 ,,	37 24 ,,	139 56 ,,	Jan. 26-02	South Coast	737	840	1·1	774
775	May 1-01	,, 'Gulf of Venice' ...	— Cook, ,,	39 41 ,	116 0 ,,	33 57 ,,	120 0 ,,	Feb. 5-02	S.W. Coast...	280	395	1·4	775
776	Oct. 31-00	,, 'Hawkes Bay' ...	A. Child, ,,	37 56 ,,	18 46 W.	3 2 ,,	40 20 W.	May 20-02	S. Atlantic...	566	2860	5·1	776
777	Aug. 29-01	R.M.S. 'Himalaya' ...	W. L. Broun, ,,	35 20 ,,	124 6 E.	33 50 ,,	123 45 E.	Jan. 22-02	South Coast	146	90	0·6	777
778	Dec. 17-01	,, ...	,, ,,	12 4 N.	53 1 ,	11 55 N	43 22 ,,	April 21-02	Gulf of Aden	125	650	5·2	778
779	July 19-00	R.M.S. 'India'	W. D. G. Worcester, R.N.R.	35 12 S	124 52 ,,	32 10 S.	128 5 ,,	Feb. 2-02	South Coast	562	250	0·4	779
780	June 3-01	,, ...	,,	28 29 ,,	112 2 ,,	33 4 ,,	115 45 ,,	July 6-02	West Coast	398	354	0·9	780
781	Sept. 27-01	,, ...	,,	8 6 N	72 59 ,,	9 48 N.	80 12 ,,	Mar. 21-02	Arabian Sea	175	490	2.8	781
782	Nov. 6-01	,, ...	,,	37 10 S.	139 29 ,,	37 26 S.	139 58 ,,	Dec. 1-01	South Coast	25	33	1.3	782
783	Nov. 9-01	,, ...	,,	35 27 ,,	124 16 ,,	33 52 ,,	123 38 ,,	Jan. 22-02	,,	74	95	1·3	783
784	Nov. 27-01	,, ...	,,	12 31 N.	47 29 ,,	12 45 N.	41 40 ,,	Dec 29-01	Gulf of Aden	32	400	12 5	784
785	Jan. 28-02	,, ...	,,	12 11 ,,	51 21 ,,	10 50 ,,	46 0 ,,	Feb. 9-02	,,	12	350	29·2	785
786	Feb. 13-02	,, ...	,,	35 5 S.	116 25 ,,	35 0 S.	116 48 ,,	March 9-02	S.W. Coast...	25	22	0·9	786
787	Feb 16-02	,, ...	,,	35 18 ,,	137 45 ,,	34 43 ,,	138 35 ,,	April 3-02	South Coast	46	58	1·3	787

OCEAN CURRENTS.

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788	April 24-01	S.S. 'Kadina' ...	H. T. Boso, Commander ...	37 24 S.	133 47 E.	38 5 S.	144 25 E.	Dec. 14-01	South Coast	234	636	2·7	788
789	June 29-00	,, 'Kasuga Maru'	E. W. Haswell, ,, ...	29 34 ,,	153 28 ,,	18 33 ,,	146 19 ,,	Dec. 19-01	East Coast ..	538	825	1·5	789
790	April 7-02	,, ,, ...	— Frazer, ,, ...	19 29 ,,	147 50 ,,	19 6 ,,	146 52 ,,	April 28-02	,,	21	67	3·2	790
791	Feb. 9-02	,, 'Kumano Maru'	E. W. Haswell, ,,	24 43 ,,	153 26 ,,	24 40 ,,	153 19 ,,	Mar. 1-02	,,	20	8	0·4	791
792	Mar. 7-02	,, 'Langton Grange'	C. T. Crichton, ,, ..	39 2 ,,	146 44 ,,	37 55 ,,	148 0 ,,	Mar. 29-02	South Coast	22	93	4·2	792
793	Nov. 14-01	Ship 'Lismore' ...	J. Wilson, Master	48 53 ,,	166 30 ,,	143 52 ,,	173 0 ,,	Feb. 21-02	S. N. Zealand	99	400	4·0	793
794	Nov. 18-01	S.S. 'Macquarie' ...	F. W. Corner, R.N.R., Com.	39 0 ,,	140 10 ,,	37 52 ,,	140 18 ,,	Dec. 20-01	South Coast	32	60	1·9	794
795	Feb. 11-01	,, 'Manapouri' ...	F. Crawshaw, Commander	7 0 ,,	178 25 ,,	22 5 ,,	149 55 ,,	Jan. 18-02	Oceania ..	341	2164	6·3	795
796	May 12-01	,, ...	,, ,,	26 2 ,,	163 52 ,,	15 6 ,,	145 20 ,,	Dec. 23-01	South Pacific	225	1566	7·0	796
797	Aug. 30-01	,, ...	,, ,,	31 4 ,,	158 0 ,,	33 4 ,,	151 40 ,,	Dec. 29-01	East Coast ..	121	390	3·2	797
798	Nov. 10-01	,, ...	,, ,,	22 30 ,,	176 15 W.	19 6 ,,	178 12 ,,	Feb. 12-02	Oceania ...	94	250	2·7	798
799	Feb. 13-02	,, ...	,, ,,	31 33 ,,	157 26 E.	24 40 ,,	153 28 ,,	July 10-02	East Coast...	147	480	3·3	799
800	Feb. 18-02	,, ...	,, ,,	19 27 ,,	176 53 ,,	21 30 ,,	168 20 ,,	April 20-02	Oceania ...	61	130	2·1	800
801	Feb. 23-02	,, ...	,, ,,	16 17 ,,	178 7 W.	18 12 ,,	178 54 W.	Mar. 25-02	,,	30	136	4·5	801
802	Jan. 4-01	G.M.S. 'Moewe' ...	— Feiferling, ,,	29 25 ,,	154 2 E	32 45 ,,	152 5 E.	...	East Coast ..	...	230	...	802
803	Oct. 20-99	R.M.S. 'Miowera' ...	F. A. Hemming, ,,	2 28 N.	178 27 W	11 43 N	142 35 ,,	Oct. 1-01	North Pacific	711	2725	3·8	803
804	May 4-01	,, 'Monowai' ...	C. Spinks, ,,	39 24 S.	169 47 E.	35 45 ,,	173 36 ,,	July 25-03	New Zealand	447	290	0·6	804
805	Oct. 19-01	,, ...	,, ,,	44 2 ,,	158 41 ,,	38 58 ,,	174 15 ,,	Mar. 12-02	Tasman Sea	144	850	5·9	805
806	Oct. 21-01	,, ...	,, ,,	44 11 ,,	160 58 ,,	40 47 ,,	175 7 ,,	July 12-02	,,	264	720	2·7	806
807	Oct. 22-01	,, ...	,, ,,	44 9 ,,	160 59 ,,	43 26 ,,	169 57 ,,	Mar. 7-02	,,	136	450	3·3	807
808	Nov. 12-01	,, ...	,, ,,	39 12 ,,	169 31 ,,	36 20 ,,	174 12 ,,	Jan. 11-02	New Zealand	60	305	5·1	808
809	Aug. 6-01	S S 'Moravian' ...	A. Simpson, ,,	39 37 ,,	137 0 ,,	37 46 ,,	149 10 ,,	Dec. 8-01	South Coast	124	680	5·5	809
810	Aug. 6-01	,, ...	,, ,,	39 37 ,,	137 0 ,,	38 40 ,,	145 35 ,,	Jan. 10-02	,,	157	470	3·4	810
811	June 9-01	,, 'Narrung' ...	A. W. Bond, R.N.R., ,,	38 3 ,,	122 3 ,,	36 10 ,,	139 20 ,,	Feb. 15-02	,,	252	940	3·7	811
812	Sept. 7-01	R.M.S. 'Orizaba' ...	R. Archer, ,,	35 30 ,,	126 13 ,,	33 50 ,,	121 58 ,,	Feb. 14-02	,,	160	250	1·6	812
813	Dec. 29-01	,, ...	,, ,,	35 19 ,,	119 53 ,,	34 38 ,,	118 30 ,,	April 12-02	,,	104	89	0·9	813
814	Jan. 12-02	,, 'Oroya' ...	R. Fletcher, ,,	35 18 ,,	119 51 ,,	34 5 ,,	119 45 ,,	April 10-02	,,	88	69	0·8	814
815	Feb. 5-02	,, 'Oruba' ...	W. H. Burgoin, ,,	37 26 ,,	139 37 ,,	35 44 ,,	139 15 ,,	Feb. 27-02	,,	22	84	3·8	815
816	Nov. 16-00	M.M.S.S. 'Pacifique'	— Couret, ,,	25 30 ,,	162 40 ,,	25 11 ,,	152 50 ,,	Feb. 25-02	East Coast...	466	630	1·4	816
817	Sept. 21-01	,, ,, ...	,, ,,	23 7 ,,	165 35 ,,	28 40 ,,	153 40 ,,	April 26-02	,,	218	818	3·8	817
818	Oct. 16-99	,, 'Polynésien' ...	A. Chevalier, ,,	26 41 ,,	158 40 ,,	21 40 ,,	149 22 ,,	Jan. 23-02	,,	829	630	0·8	818
819	Sept. 8-00	,, ,, ...	,, ,,	29 54 ,,	110 17 ,,	28 22 ,,	114 17 ,,	May 7-01	West Coast	241	262	1·1	819
820	Sep. 19-00	,, ,, ...	,, ,,	30 32 ,,	153 50 ,,	25 52 ,,	153 10 ,,	Feb. 11-02	East Coast...	510	291	0·6	820
821	May 1-01	,, ,, ...	,, ,,	28 36 ,,	158 12 ,,	23 0 ,,	149 50 ,,	...	,,	...	620	...	821
822	Aug. 24-01	,, ,, ...	,, ,,	29 22 ,,	155 0 ,,	23 16 ,,	151 20 ,,	Jan. 12-02	,,	141	440	3·1	822
823	Aug. 25-01	,, ,, ...	,, ,,	25 21 ,,	160 3 ,,	21 30 ,,	149 18 ,,	Feb. 2-02	,,	192	730	3·8	823

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824	Aug. 29-01	M.M.S.S. 'Polynésien' ...	A. Chevalier, Commander	27 9 S	158 19 E.	24 40 S.	152 12 E.	Mar. 26-02	East Coast ..	209	414	2·0	824
825	Jan. 5-02	S.S. 'Rockton'	M. M. Osborne, "	38 45 ,,	147 20 ,,	37 45 ,,	148 48 ,,	Mar. 15-02	South Coast	69	98	1·4	825
826	Mar. 2-02	"	" "	39 8 ,,	146 29 ,,	38 45 ,,	144 40 ,,	Mar. 17-02	"	15	102	6·8	826
827	Sept. 17-01	R.M.S. 'Rome'	E. Street, "	30 38 ,,	114 12 ,,	28 22 ,,	114 20 ,,	Dec. 16 01	"	90	139	1·5	827
828	Aug. 7-00	H.M.S. 'Royalist'	J. E. T. Glossop, "	16 0 ,,	177 24 W.	16 28 ,,	179 41 W.	Dec. 23-00	Fiji	138	91	0·7	828
829	Nov. 20-01	S.S. 'Star of New Zealand'	J. M. Hart, "	4 59 N	13 39 ,,	5 10 N.	3 40 ,,	...	West Africa	...	690	...	829
830	Dec. 20-01	" ...	" "	40 15 S	140 11 E.	38 2 S.	140 41 E.	Mar. 2-02	South. Ocean	72	124	1·7	830
831	July 26-01	" 'Sussex'	B. Hayward, "	33 0 ,,	124 18 ,,	33 55 ,,	123 27 ,,	Jan. 21-02	South Coast	179	51	0·3	831
832	Sept. 1-01	Barquentine 'Volador' ...	D. A. Sharp, Master ...	36 0 ,,	169 15 ,,	35 5 ,,	173 12 ,,	June 11-02	New Zealand	283	230	0·8	832
833	Mar. 30-01	R.M.S. 'Victoria'	F. C A. Lyon, R.N.R., Com.	35 44 ,,	125 44 ,,	32 0 ,,	132 45 ,,	Jan. 5-02	South Coast	281	455	1·6	833
834	May 12-01	"	" "	8 51 N	68 11 ,,	7 38 N.	81 42 ,,	Feb. 14-02	Arabian Sea	278	925	3·3	834
835	July 30-01	"	" "	27 40 S	110 52 ,,	28 28 S.	114 26 ,,	April 21-02	South Coast	265	220	0·8	835
836	Sept. 20-01	"	" "	12 31 N.	44 30 ,,	13 20 N	43 14 ,,	July 4-02	Gulf of Aden	287	97	0·3	836
837	July 14-01	M.M.S.S. 'Ville de la Ciotat'	A. Fiaschi, "	36 55 S.	127 38 ,,	35 50 S.	139 23 ,,	Dec. 24-01	South Coast	163	670	4·1	837
838	June 7-01	" ...	" "	29 15 ,,	157 51 ,,	32 15 ,,	152 29 ,,	April 9-02	East Coast...	306	360	1·2	838

The following Current Papers Nos. 839 to 878 have been supplied by Capt A. Simpson.

Ref. No.	Date when put into the sea	Name of Ship.	Name.	Thrown Over. Lat. ° ′	Thrown Over. Long. ° ′	Where Found. Lat. ° ′	Where Found. Long. ° ′	Date when Found.	Locality.	Interval Days.	Estimated Distance in Miles.	Rate per Day.	Ref. No.
839	May 30-01	S.S. 'Moravian'	A. Simpson, Commander...	12 43 N	17 19 W.	12 20 N.	16 15 W.	Aug. 26-01	West Africa	88	77	0·9	839
840	April 11-01	"	" " ...	38 29 S.	141 35 E.	38 50 S.	142 55 E.	June 3-01	South Coast	55	92	1·7	840
841	Dec. 23-99	"	" " ...	43 20 ,,	130 8 ,,	41 30 ,,	175 0 ,,	Feb. 20-01	South. Ocean	424	2070	4·9	841
842	Feb. 5-01	"	" " ...	36 8 N	4 2 W	35 45 N.	0 47 W.	Mar. 8-01	W.Ct., Spain	31	184	5·9	842
843	Feb. 7-01	"	" " ...	48 5 ,,	5 50 ,,	48 49 ,,	3 2 ,,	Feb 7-01	Bay of Biscay	36	184	5·1	843
844	Dec. 10-00	"	" " ...	34 16 S.	25 8 E.	34 0 S.	24 57 E	Feb. 16-01	South Africa	68	24	0·4	844
845	Nov. 10-00	"	" " ...	36 11 ,,	150 36 ,,	36 14 ,,	150 9 ,,	Dec. 17-00	S. E. Coast ..	37	27	0·7	845
846	Aug. 4-00	"	" " ...	9 9 N	16 24 W.	8 30 N.	13 10 W.	Sept. 6-00	West Africa	33	220	6·7	846
847	Oct. 4-01	"	" " ...	34 53 S.	19 55 E.	34 43 S.	20 7 E.	Oct. 9-01	South Africa	5	23	4·6	847
848	Oct. 3-01	"	" " ...	34 21 ,,	21 42 ,,	34 49 ,,	19 53 ,,	Oct, 13-01	"	10	295	29·5	848
849	July 6-01	"	" " ...	10 40 N.	16 56 W.	11 5 N	15 5 W.	July 29-01	West Africa	22	138	6·3	849
850	May 28-01	"	" " ...	5 8 ,,	13 22 ,,	6 43 ,,	11 23 ,,	June 24-01	"	26	172	6·6	850
851	Feb. 5-01	"	" " ...	36 8 ,,	4 2 ,,	38 10 ,,	0 30 ,,	Aug. 20-01	S. Ct., Spain	196	299	1·5	851
852	Nov. 22-99	"	" " ...	23 43 ,,	16 57 ,,	21 15 ,,	73 0 ,,	Mar. 17-01	N. Atlantic...	480	4140	8·6	852
853	July 7-99	"	" " ...	9 32 ,,	16 12 ,,	11 0 ,,	15 40 ,,	Nov. 21-99	West Africa	137	93	0·7	853
854	Feb. 17-00	"	" " ...	34 46 S.	19 13 E.	34 6 S.	18 29 E.	Feb. 20-00	South Africa	3	63	21·0	854
855	Jan. 28-00	"	" " ...	34 47 ,,	118 57 ,,	34 30 ,,	118 50 ,,	Feb. 5-00	S.W. Coast ..	8	21	2·6	855
856	Oct. 25-99	"	" " ...	42 43 N	10 13 W.	43 30 N	3 47 W.	Jan. 23-00	W.Ct., Spain	90	358	4·0	856
857	Sept. 8-99	"	" " ...	37 33 S.	135 51 E.	34 45 S.	137 54 E.	Dec. 24-99	South Coast	107	290	2·7	857

Ref. No	Date when put into the sea.	Name of Ship.	Name.	Thrown Over. Lat. ° ′	Thrown Over. Long. ° ′	Where Found. Lat. ° ′	Where Found. Long. ° ′	Date when Found.	Locality	Interval Days.	Estimated Distance in Miles.	Rate per Day.	Ref. No.
858	Feb. 17-00	S.S. 'Moravian'	A. Simpson, Commander	34 46 S.	19 13 E.	34 6 S.	18 29 E.	Feb. 19-00	South Africa	2	65	32·5	858
859	July 7-99	,, ...	,, ,, ...	9 32 N.	16 12 W	11 7 N	15 5 W.	Oct. 21-99	West Africa	106	130	1·2	859
860	Jan. 24-00	,, ...	,, ,, ..	38 18 S	140 48 E.	38 21 S	141 36 E.	Feb. 4-00	South Coast	11	63	5·7	860
861	Nov. 17-99	,, ...	,, ,,	45 18 N.	7 34 W.	43 30 N	1 35 W.	Feb. 1-00	Bay of Biscay	76	370	4·9	861
862	Jan. 24-00	,, ...	,, ,,	38 18 S.	140 48 E.	38 18 S.	141 37 E.	Feb 17-00	South Coast	23	81	3·5	862
863	Sept. 7-99	,, ...	,, ,, ..	38 27 ,,	141 56 ,,	38 25 ,,	141 37 ,,	Sept. 17-99	,,	10	19	1·9	863
864	May 14-97	S.S. 'Thermopylæ' .	,, ,, ...	33 5 N	14 52 ,,	26 50 N	77 30 W.	July 7-99	N.W. Africa	784	4715	6·0	864
865	July 18-99	,, 'Moravian'	,, ,,	32 44 S	17 26 ,,	34 13 S.	22 0 E	Oct. 3-99	South Africa	77	378	4·9	865
866	July 8-99	,, ...	,, ,,	5 31 N.	13 22 W.	7 45 N.	12 30 W.	Aug. 5-99	West Africa	18	172	9·6	866
867	Jan. 8-98	,, 'Thermopylæ' ...	,, ,, .	45 34 S	117 13 E.	40 0 S	177 0 E.	May 23-99	South. Ocean	500	3105	6·2	867
868	Jan 7-98	,, ...	,, ,, .	45 22 ,,	109 2 ,,	41 45 ,,	171 50 ,,	Dec. 19-98	,,	346	3185	9·2	868
869	Jan. 8-98	,, ...	,, ,, ...	45 34 ,,	117 13 ,,	40 10 ,,	175 20 ,,	Nov 18-98	,,	314	3007	9·6	869
870	June 1 98	,, 'Aorangi' ..	,, ,, ..	36 30 ,,	163 30 ,,	40 10 ,,	175 20 ,,	Aug. 15-98	Tasman Sea	75	692	9·2	870
871*	Jan. 30-98	,, 'Thermopylæ' ..	,, ,,	38 39 ,,	141 2 ,,	38 22 ,,	144 15 ,,	Feb. 20-98	South Coast	21	23	1·1	871
872	Oct. 15-97	,, ...	,, ,, ...	22 49 N	17 8 W	16 50 N	25 18 W.	Dec. 22-97	N.W. Africa	68	667	9·8	872
873	Oct. 11-97	,, ...	,, ,, ...	6 21 ,,	14 17 ,,	5 10 ,,	2 10 ,,	May 1-98	West Africa	202	1061	5·4	873
874	Dec. 8-97	,, ...	,, ,, .	21 1 ,,	17 44 ,,	16 54 ,,	25 18 ,,	Feb. 8-98	N.W. Africa	61	568	9·3	874
875	July 30-97	,, ...	,, ,,	41 54 S	76 15 E.	35 0 S	117 55 E.	Jan. 27-98	South. Ocean	181	2358	13·0	875
876	Oct. 21-97	,, ...	,, ,, ...	47 43 N.	6 37 W.	51 43 N	5 30 W.	Jan. 6-98	Bay of Biscay	77	297	3 9	876
877	Jan 11-98	,, ...	,, ,, ..	41 10 S	136 48 E.	38 45 S.	143 30 E.	May 6-98	South Coast	115	390	3·4	877
878	Sept. 1-94	,, ...	,, ,,	40 28 ,,	137 31 ,,	42 0 ,,	145 9 ,,	Feb. 10-95	,,	162	413	2·5	878

* NOTE—Two papers put over at same time and found near each other by the same man

The following papers have been received since the previous lists were arranged.

Ref. No	Date when put into the sea.	Name of Ship.	Name.	Thrown Over. Lat.	Thrown Over. Long.	Where Found. Lat.	Where Found. Long.	Date when Found.	Locality	Interval Days.	Estimated Distance in Miles.	Rate per Day.	Ref. No.
879	July 16-02	R.M.S. 'Aorangi'	J. D S. Phillips, Command	22 49 S	168 49 E	22 41 S	167 20 E.	July 31-02	South Pacific	15	96	6·4	879
880	May 14-02	,, 'Austral'	C. Nicholson, ,,	30 52 ,,	114 08 ,,	32 16 ,,	115 42 ,,	May 23-02	S.W. Coast...	9	124	13·8	880
881	Mar. 31-02	,, 'Australia'	F. Cole, ,,	36 32 ,,	138 52 ,,	35 45 ,,	139 10 ,,	May 15-02	South Coast	46	48	1·1	881
882	Jan. 26-02	M.M.S S. 'Australien' ...	C. Verron, ,,	36 1 ,,	119 52 ,,	33 53 ,,	120 45 ,,	June 29-02	S W. Coast...	154	132	0·9	882
883	Dec. 7-01	R.M.S. 'Britannia' ...	F. H. Seymour, ,,	35 26 ,,	124 41 ,,	35 24 ,,	139 53 ,,	Aug. 27-02	South Coast	263	867	3·3	883
884	April 13-02	,, ...	,, ,,	35 15 ,,	117 19 ,,	34 45 ,,	118 32 ,,	April 26-02	S W. Coast .	13	75	5·8	884
885	Aug. 27-02	,, ...	,, ,,	37 26 ,,	139 45 ,,	37 36 ,,	140 07 ,,	Sept. 4-02	South Coast	8	25	3·1	885
886	April 29-01	S S. 'Gulf of Venice' ...	— Cook, ,,	40 18 ,,	105 53 ,,	39 10 ,,	144 30 ,,	Sept. 19-02	South. Ocean	508	2120	4·2	886
887	Dec. 1-01	R.M.S. 'India'	W. D. G. Worcester, R.N R.	27 35 N	34 01 ,,	19 10 N	37 10 ,,	April 12-02	Red Sea ...	132	579	4·4	887
888	Jan. 19-02	,, ...	,, ...	37 05 ,,	17 40 ,,	42 08 ,,	15 32 ,,	Aug. 2-02	Mediterranean	195	292	1·1	888
889	Feb. 20 02	,, ...	,, ...	37 53 S.	149 32 ,,	37 36 S.	149 50 ,,	Sept. 26-02	S E. Coast ...	218	23	0·1	889
890	Mar. 14-02	,, ...	,, ...	35 35 ,,	132 02 ,,	39 44 ,,	144 0 ,,	Oct. 9-02	South Coast	209	700	3·3	890

Ref. No.	Date when put into the sea.	Name of Ship.	Name.	Thrown Over. Lat. ° ′	Thrown Over. Long. ° ′	Where Found. Lat. ° ′	Where Found. Long. ° ′	Date when Found.	Locality.	Interval Days.	Estimated Distance in Miles.	Rate per Day.	Ref. No.
891	Sept. 30-99	S.S. 'Indraghiri'	G. W. Harwood, Command.	47 49 S.	48 28 W	29 05 S	114 40 E.	May 24-02	South. Ocean	966	9020	9·3	891
892	Mar. 22-01	,, ...	,, ,, ..	45 18 ,,	58 25 E.	39 44 ,,	144 0 ,,	June 29-02	,,	464	4375	9·4	892
893	Nov. 7-01	,, ...	,, ,, ..	43 27 ,,	128 0 ,,	35 47 ,,	137 46 ,,	May 5-02	South Coast	179	545	3·0	893
894	Dec 11-00	,, 'Kasuga Maru' ...	E. W. Haswell, ,, .	31 34 ,,	155 1 ,,	28 58 ,,	168 3 ,,	Aug. 26-02	East Coast...	623	800	1·3	894
895	June 22-02	,, ...	,, ,, ...	37 33 ,,	149 54 ,,	32 43 ,,	152 9 ,,	Sept. 16-02	South Coast	86	356	4·1	895
896	Mar. 8-02	,, 'Langton Grange' ...	C. T. Crichton, ,, ...	39 1 ,,	141 55 ,,	38 5 ,,	141 3 ,,	June 12-02	,,	96	70	0·6	896
897	Dec. 17-99	,, 'Manapouri'	G. Crawshaw, ,, ...	29 2 ,,	159 50 ,,	27 20 ,,	153 31 ,,	Mar 18-02	East Coast .	456	397	0·9	897
898	Nov. 30-01	,, ...	,, ,, ...	15 19 ,,	175 12 W.	17 0 ,,	177 20 ,,	April 18-02	South Pacific	139	516	3·7	898
899	Jan. 4-02	,, ...	,, ,, ...	24 30 ,,	176 55 ,,	18 15 ,,	178 7 ,,	June 14-02	,,	161	520	3·2	999
900	Jan. 26-02	,, ...	,, ,, ...	15 47 ,,	176 33 ,,	16 47 ,,	177 31 ,,	April 24-02	,,	88	400	4·5	900
901	Feb 14-02	,, ...	,, ,, ..	29 15 ,,	161 38 E.	16 20 ,,	145 26 ,	Sept. 24 02	East Coast ..	222	1315	5·9	901
902	Oct. 21-01	,, 'Monowai'	H. W. H. Chatfield, Com .	44 7 ,,	161 4 ,,	37 28 ,,	174 43 ,,	June 10-02	Tasman Sea	232	806	3·5	902
903	May 14-02	,, ...	C. McArthur, ,, ...	40 2 ,,	171 31 ,,	33 10 ,	174 42 ,,	June 5-02	,,	22	218	9·9	903
904	Aug. 30 02	,, 'Moonta"	C. Ulhrich, ,, .	30 23 ,,	114 55 ,,	30 11 ,,	115 0 ,,	Sept. 2-02	West Coast	3	13	4·3	904
905	May 8-02	Ship 'Mount Stewart' ...	Chas Green, Master	40 0 ,,	135 40 ,,	37 55 ,,	140 23 ,,	Sept. 28-02	South Coast	143	278	1·9	905
906	June 4-02	S S. 'Narrung'	A. W. Bond, R N.R , Com .	33 45 ,,	26 45 ,,	33 43 ,,	26 20 ,,	June 11-02	Cape Colony	7	24	3·4	906
907	July 14-01	,, 'Neotsfield"	J. B Rugg, ,, ..	41 50 ,,	78 32 ,,	38 16 ,,	141 45 ,,	May 15-02	South. Ocean	305	3355	11·0	907
908	April 30-02	R.M.S 'Orizaba'	R. Archer, ,, ..	4 38 N.	81 37 ,,	8 0 N	93 20 ,,	Aug. 9-02	Indian Ocean	91	840	9·2	908
909	Jan. 11-02	,, 'Oroya'	R. Fletcher, ,, .	35 23 S.	125 36 ,,	33 54 S.	122 40 ,,	May 10-02	South Coast	119	188	1·6	909
910	May 2-02	,, 'Oruba'	W. H. Burgoin, ,, .	35 15 ,,	117 59 ,,	34 9 ,,	119 49 ,,	.	S.W. Coast	...	122	..	910
911	May 6-02	,, ...	,, ,, ...	37 39 ,,	139 53 ,,	35 3 ,,	140 52 ,,	June 18-02	South Coast	43	157	3·7	911
912	Sept. 16-01	M.M S.S. 'Polynésien'	A. Chevalier, ,, ..	20 30 ,,	100 50 ,,	20 40 ,,	57 20 ,,	Aug. 15-02	Indian Ocean	323	2828	8·8	912
913	April 11-01	,, Ville de la Ciotat'	A. Fiaschi, ,, ..	33 34 ,,	151 41 ,,	24 45 ,,	153 35 ,,	April 23-02	East Coast ..	377	550	1·5	913
914	Aug. 20-01	S.S. 'Waihora'	C. McDonald, ,, ..	38 34 ,,	166 18 ,,	36 53 ,,	174 25 ,,	June 22-02	Tasman Sea	306	457	1·3	914
915	Aug. 20-01	,, ...	,, ,, ..	38 34 ,,	166 18 ,,	37 38 ,,	174 45 ,,	April 27-02	,,	250	478	1·9	915
916	Oct. 2-01	R.M.S. 'Himalaya' ..	W. L Broun, ,, ...	24 16 ,,	107 52 ,,	0 42 N	41 23 ,,	Aug. 22-02	Indian Ocean	324	4820	14·9	916
917	May 24-02	,, 'Aorangi'	J. D S. Phillips, ,, .	23 25 ,,	166 20 ,,	22 41 S	167 20 ,,	Sept. 11-02	South Pacific	110	80	0·7	917
918	Mar. 22-02	,, 'Arcadia'	F. C A. Lyon, R.N.R., Com	21 11 N.	37 58 ,,	14 4 N	42 45 ,,	Sept. 25-02	Red Sea	187	560	3·0	918
919	Feb. 9-01	Ship 'Jas. H Bruce' ...	C. G F. Peterson, Master	34 20 S	171 50 W.	19 54 S	173 24 W.	Sept. 30-02	South Pacific	598	890	1·5	919
920	Mar 11-02	S S 'Langton Grange' .	C. Crichton, Commander ..	38 14 ,,	127 30 E.	40 24 ,,	144 52 E.	Oct. 19-02	South. Ocean	222	942	4·2	920
921	May 24-02	R.M.S 'Arcadia'	F C A. Lyon, R N.R , Com.	35 41 ,,	130 10 ,,	34 15 ,,	137 31 ,,	Oct. 20-02	South Coast	149	430	2·9	921
922	Oct. 7-02	S.S. 'Monowai'	R. Neville, Commander .	45 58 ,,	164 1 ,,	49 22 ,,	168 14 ,,	Oct. 26-02	Tasman Sea	19	200	10·5	922
923	Sept. 11-02	M.M.S S. 'Armand Behic'	Le Coispellier, ,, ...	38 46 ,,	144 58 ,,	34 27 ,,	150 57 ,,	Nov. 1-02	East Coast .	51	510	10·0	923
924	Oct. 21-02	S.S. 'Eastern'	W. Ellis, ,, ...	31 54 ,,	153 22 ,,	30 55 ,,	152 57 ,,	Nov. 2-02	,,	12	64	5·3	924
925	April 20-02	M.M S.S 'Ville de la Ciotat'	A. Fiaschi ,, ...	37 6 ,,	127 50 ,,	38 17 ,,	141 42 ,,	Nov. 2-02	South Coast	196	779	3·9	925
926	Oct. 5-02	N.Y.K. 'Kasuga Maru' ...	— Frazer, ,, ...	23 19 ,,	152 16 ,,	25 10 ,,	152 41 ,,	Nov. 4-02	East Coast...	31	140	4·5	926

FORESTS CONSIDERED IN THEIR RELATION TO RAINFALL AND THE CONSERVATION OF MOISTURE.

By J. H. MAIDEN.

[*Read before the Royal Society of N. S. Wales, November 5, 1902.*]

SYNOPSIS.

I. INTRODUCTORY.

I bring before you the subject which is often conventionally known under the title of "Forests and Rainfall," and in regard to which it may be fairly said that there still exists, in New South Wales at least, a considerable amount of misapprehension. Even the clear cut statements of Mr. Russell, our Government Astronomer, that forests do not increase rainfall, have failed to carry conviction to some people, for the reason, I take it, that the broader subject of the effect of vegetation on the *conservation* of moisture has

not been fully considered in some of the public discussions that have taken place. The term "Forests and Rainfall" has been adopted by many writers because of its compactness, but if its use becomes misleading then it should be amplified. We want to carefully separate two issues.

1. The effect of forests and other vegetation in increasing the rainfall.
2. The effects of the same in conserving moisture.

I do not approach the subject with any but the most elementary meteorological knowledge, but I have had much experience of Australian forestry. Taking an extensive territory, it appears to be indisputably proved that forests do not increase rainfall; it is fully as well proved that they conserve the rain that falls, and therefore every effort should be made to save them from unnecessary destruction.

A thoughtful paper by Mr. Walter Gill,[1] Conservator of Forests of South Australia, is well worthy of perusal. He deals with evidence gathered from official reports and other sources, in different countries, in regard to the effects of forests and their destruction on the rainfall and available moisture generally. The paper is temperately worded and contains much sound advice, which should be well pondered over by "every individual member of an intelligent democracy."

Let me invite attention to Bulletin No. 7 of the Forestry Division of the U.S. Department of Agriculture, entitled "Forest Influences." It contains masterly papers by Professors M. W. Harrington and B. E. Fernow, to which I am much indebted.

There is so much postulation, theory and uncertainty of observations, in regard to the whole subject, that I am

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[1] "Deforestation in South Australia; its causes and probable results.' Adelaide Meeting, *Aust. Assoc. for Adv. of Science*, 1893.

unable to classify the statements as rigidly as if I were dealing with exact science; I have however, avoided repetition as far as possible.

II. The Historical Method.

a. *General observations.*—Popular writers usually rely upon the historical method in support of their well-intentioned arguments on this question, but although this method has been superseded by the scientific method, which relies on observation and experiment, it is proper to deal with historical evidence at this place.

Löffelholz-Colberg published in 1872 a comprehensive catalogue of publications on forest questions which is, of course, now much out of date. His list begins with Fernando Columbus, the son of Christopher Columbus, who attributed the heavy rainfall of Jamaica to its wealth of forests, and the decrease of rainfall on the Azores and Canaries to the removal of their forests. In the sixteenth and seventeenth centuries the subject was already attracting the attention of the French Government, and in fact governmental interest in the subject goes back to the time of the immediate successors of Charlemagne. It is interesting to read over the abstracts of opinion which are recorded by Löffelholz-Colberg. Every variety of opinion can be found there, from those which attribute to the forest about everything which is desirable in climate and even endow it with a powerful influence on morals, to those who believe it to be entirely without influence; and from those who think that its influence does not extend beyond its own margin, to those who would attribute the deterioration of the climate of the Old World to the removal of the forests of the New.

Leaving out of account the solutions which are purely sentimental or purely theoristic, the conclusions usually consist in finding a country which has been once wooded,

but from which the forests have been removed, or one which was once open, but later became wooded. The climate at the beginning and end of the time involved is then ascertained or assumed, and the changes in the climate are attributed to the change of the forest cover. The uncertainties of this method are so great as to make it generally useless. It is seldom possible to be sure of the early forest condition of any particular country. (M. W. Harrington, *op. cit.*)

b. *The case, "Forest Destruction Does Diminish the Rainfall.*"—I think that the few authors about to be cited are fairly representative of the evidence that is usually adduced. There is a certain amount of vagueness in some cases as to whether it is intended to state that the amount of rainfall is diminished by the destruction of trees. My first illustration is given because in one version or another it is so often quoted in the periodical discussions that have taken place in New South Wales.

"The most fertile of all provinces in Bucharia was that of Sogd. Malte Brun said, in 1826, "For eight days we may travel and not be out of one delicious garden." In 1876 another writer says of the same region: "Within thirty years this was one of the most fertile spots of Central Asia, a country which, when well wooded and watered, was a terrestrial paradise. But within the last twenty-five years a mania for clearing has seized upon the people, all the great forests have been cut away, and the little that remained was ravaged by fire during a civil war. The consequences followed quickly, and this country has been transformed into a kind of arid desert The water-courses are dried up and the irrigating canals are empty. . . . .

"It is certain that the fertility of these regions in ancient times was due to stupendous irrigating devices and canals, and when these were neglected, through wars and other untoward circumstances, the fertility necessarily ceased. It is certain that there

are ruins of enormous irrigating ditches and canals in Babylonia where history indicates that there was once a teeming population and great fertility, but where now only a sandy desert greets the eye."[1]

The late Sir William Hooker wrote :—

"That from Ascension there continued to be received encouraging accounts of the increased fertility and moisture of the island, consequent on the extension of the plantations."[2]

It is proper to point out that in this statement it is not asserted that the *rainfall* is alleged to have been increased.

"It is remarked by Marsh, that "it has long been a popularly settled belief that vegetation and condensation and fall of atmospheric moisture are reciprocally necessary to each other, and even the poet sings of

> "Afric's barren sand,
> Where nought can grow, because it raineth not,
> And where no rain can fall to bless the land,
> Because nought grows there."

Here we have an illustration of the converse fact: one measure of humidity promoting vegetation, and vegetation not only arrest ing the desiccation but so reversing the process that an increased humidity is the consequence."[3]

While the extract just quoted may be interpreted as not stating that forests increase rainfall, the same work contains many instances (not well classified), of the effects of the destruction of the forests and of varying degrees of value, but affording a lengthy list from which a writer working up a case can obtain his illustrations.

"In connection with the systematic destruction of timber in Australia, it is mentioned that in the Ballarat district this destruc-

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[1] Professor H. A. Hazen before Annual Meeting of American Forestry Assoc., Nashville, Tenn., U.S.A., Sept. 22nd, 1897; quoted in "Nature," 30th December, 1897, p. 213.

[2] Report of the Director of Kew Gardens for 1864.

[3] J. Croumbie Brown's "Forests and Moisture," p. 144-5.

tion has been accompanied by a corresponding diminution in the rainfall, and since 1863 there has been a more or less regular reduction from 37·27 inch in 1863 to 14·23 inch in 1868.[1] This is inconclusive, for the reason that the years referred to may have been in a rainy cycle.

"It is recorded of these, (part of Leeward Islands), that in former times, they were clothed with dense forests, and the oldest inhabitants remembered when the rains were abundant, and the hills and all uncultivated places were shaded by extensive groves. *The removal of the trees was certainly the cause of the evil.* The opening of the soil to the vertical sun rapidly dries up the moisture, and prevents the rain from sinking to the roots of plants. The rainy seasons in these climates are not continuous cloudy days, but successions of sudden showers with the sun shining hot in the intervals. Without shade upon the surface the water is rapidly exhaled, and the springs and streams diminish."[2]

See also a paper by the Rev. W. B. Clarke, M.A., F.R.S., on the "Effects of forests vegetation on climate,"[3] which contains references to a number of authors, and which provoked an interesting discussion.

A pamphlet by Mr. F. S. Peppercorne,[4] gives a number of instances of countries whose present aridity is attributed to diminished rainfall caused by extensive cutting down of trees.

"Aragu affords an interesting example of the evil influence of the wholesale destruction of trees in lessening running streams."[5]

J. Croumbie Brown, (*Op. cit.*, p. 112), gives additional information in regard to this interesting locality.

The Report of the Director of the Botanic Gardens of Adelaide for 1881, has an appendix on "The influence of

[1] "Nature," I., 291.
[2] Letter from Dr. Hooker to Lord Kimberley, 1870.
[3] This Journal 1876, 179 *et seq.*
[4] "The influence of forests on Climate and Rainfall," Napier, N.Z., 1880.
[5] J. M. Spence, "The Land of Bolivar," I., 159.

forests on climate," which mainly repeats the instances given in "The Forest" of Prof. Schacht.

Mr. J. G. O. Tepper, an earnest writer on philosphical questions pertaining to plant life, has a paper[1] which is well worthy of perusal. It enumerates a number of the oft quoted examples of altered climatic conditions attributed to destruction of forests, and also deals with the problems of physics which are involved in a proper understanding of the subject.

c. *The case, "Forest Destruction Does Not Diminish Rainfall.*—With us forest destruction takes two forms:—

(1) The felling, removal and "burning off" necessary for agricultural and other settlement, and which many thinking men are of opinion is often carried out in too drastic a manner, to the detriment of the owner of the land himself, who often finds he has got rid of shelter and timber he would afterwards be glad of.

(2) Ringbarking, which is necessary to fit much of our land for grazing purposes and which like (1) is undoubtedly done ignorantly and recklessly, particularly, I think, losing sight of the incipient creeks which are the beginnings of floods and washaways. This is a very wide question which I have dealt with on a previous occasion (*ante* page 115).

Our Government Astronomer has given special attention to the "Forests and Rainfall" subject for many years, particularly with reference to Australia, and I cannot do better than quote some of his published statements.

Mr. Russell speaks,[2] in regard to forest destruction and climate of "the tiny efforts of men" in the way of forest destruction and the enormous quantity of felling and ring-

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[1] "The influence of vegetation on climate and rainfall," read before the Royal Soc. of S.A., 3rd May, 1893 (printed by *Adelaide Observer.*)

[2] Letter to *Sydney Morning Herald*, 31 December, 1898. See also Hazen, *infra*, page 222.

barking that followed the Free Selection before Survey Act of 1861. He proceeds, "How is it that in India, where trees are conserved instead of destroyed, drought of extreme severity overtakes the country, and this too at times coincident with our droughts in Australia." He also gives instances of droughts in the Pacific Islands and South Africa.

Mr. Russell formally reported on the subject and his report was laid before Parliament on 30th November 1898. He quotes the report of the Meteorological Society of Edinburgh in 1859, in connection with the Forests and Rainfall question, which stated that "there were no grounds for thinking the rainfall of Western Europe was getting less." He adds—

"An elaborate investigation of the rainfall records by Mr. Symons (the highest authority on such matters in England) had led to a similar conclusion. An investigation carried out in the United States by the Smithsonian Institution resulted in a decision that no evidence was to be found of a decreasing rainfall, and in America they had destroyed forests wholesale. Professor Marsh in his book "The earth as modified by human action," had discussed the question fully, and after considering all the available evidence, he concluded that there was no evidence that the annual rainfall had diminished by the action of man in the destruction of trees. . . . . Those parts of the State which had suffered most from the drought—Western Riverina and the Darling country—had done practically no ringbarking."

Mr. Russell adds,

. . . "so far as New South Wales is concerned, he felt quite certain that the destruction of trees had not decreased the rainfall, but would rather appear to have increased it.[1] As an instance

[1] I have dealt with the subject of natural forest growths appearing without human agency in my Presidential Address, Proc. Linn. Soc., N.S.W., 1902, page 785, and would say that we have few data as to the net forest area in New South Wales, showing how forest destruction is balanced against planted and natural growth.

the average rainfall over the whole colony, 1889 to 1894 inclusive, was 24·7 per cent. above the average of all years."

Mr. T. Kidston, a gentleman of much experience, states, "I entirely dissent from the opinion that forest destruction diminishes rainfall. I have been through Upper and Lower Canada, Nova Scotia, and the New England States of North America, where the greatest amount of timber-cutting has taken place in the world's history, in a like time, and yet the rainfall statistics show that during the last sixty years the rainfall has slowly, yet continuously *risen*, and one of the most eminent meteorologists (Prof. Marsh, from memory), after a life-long study, has recorded his opinion "that rainfall is not increased or diminised by anything that man has done, but by some great cause, *external to the earth*." In this western[1] country, if ridden over, a fortnight after a fall of 2 or 3 inches of rain, it will be found soft and boggy, if ringbarked, but the adjoining unringed country will be comparatively firm and sound. In the latter (green timbered country), the enormously increased evaporating surface of the leafage, compared with the area of the plot occupied by the tree, has carried the moisture off into the air, which is still retained in the soil among the dead ringbarked timber, and the grasses are nourished long after the soil among the live trees is parched and dry. The main cause of the water disappearing more rapidly from rolling or hilly country now than formerly is the solidification of the soil by the trampling of stock, more especially sheep. In Western Queensland, or any new country, before being stocked, the surface was soft and spongy and a large part of the rainfall sank directly into the soil. Now, when trodden down and hardened by stock, the water more readily runs off, and so tends to form creeks and water-holes, which did not formerly exist. The sheep also trod into the damp soil the pine seed which formerly perished on the surface, or was swept into the rivers by heavy rains. Hardening

[1] "Ringbarking in Western New South Wales," *Agric. Gazette*, N.S.W. November, 1894.

the surface soil will account for the more rapid rise of floods and the greater erosion of river-beds."

Mr. R. Wyndham writes:—[1]

"The Hunter River Valley is now, generally speaking, all ring-barked, with the result that now dry creeks are running creeks, and dry gullies have water-holes in them. . . . Before the valley was ringbarked, the Hunter River was generally a chain of water-holes every summer, now it is always a running stream. I have no fear of ringbarking causing droughts, but I fear it will cause higher floods, as it stands to reason that creeks and gullies full of water cannot carry off the rain that dry creeks and gullies can." . . . "To show how trees make the ground dry and hard, I may mention that I once gave a contract for fencing on ringbarked country where I had clumps of trees left for cattle camps. The fence went through one of these clumps, and the ground was so hard that the men had great difficulty in getting down their post-holes."

The writer forgets that cattle make ground very hard around shelter trees, through trampling. The trampling of cattle in its effects of hardening the soil, of forming tracks and incipient water channels, breaking down the banks of water-courses and setting up new conditions, is a most important factor in connection with the conservation of water and the mitigation of floods.

* * *

The question of ringbarking is a most important one in connection with my subject. I have already referred to it incidentally, and it is worthy of a little more emphasis in this place.

One writer says,

"Squatters know the value of shade too much to carry the practice (of ringbarking) to too great an extent."

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[1] *Sydney Morning Herald,* 10th January, 1899.

Another says,

"The number of persons who give the matter a second thought is very small."

I would ask, how many gentlemen in New South Wales have ever critically supervised ringbarking on their holdings? Is it not usually "So many acres to ringbark—so much per acre?" Are important details connected with the topography of the land dealt with, or in many cases, even thought of?

Most thoughtful men are of opinion that additional restrictions should be imposed on ringbarking on Crown Lands. Mr. Inspector Forester Manton[1] speaks very clearly as to the situation in the Murray River district.

I do not oppose ringbarking; it would be absurd to do so, for the effect on the grasses is not open to question, and trees are sometimes killed because they afford shelter for vermin, but I am speaking of careless ringbarking. I repeat, without any fear of effective contradiction, that there is much room for more intelligent control of ringbarking in regard to the following points:—

1. Proper time to minimise suckering.
2. Valuable timber and shade trees should not be unnecessarily sacrificed.
3. The position of a tree with respect to the natural getaway of water in a particular paddock or mountain side should be considered.

III. The Vastness of Rainfall Conditions.

The quotations that I give should need no comment from me, but I would draw attention to the point that, in Australia, to go no farther, the fact that the conditions for a fall of rain may originate in a distant part of our

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[1] "Notes on Ringbarking and Sapping, based on Foresters' Reports," *Agric. Gazette, N.S.W.*, January 1894.

planet, is very imperfectly realized. I have travelled much in New South Wales, and I am sure that it would conduce to a better understanding of the subject by our people if they would lay to heart this fundamental and wide-reaching truth.

"When we reflect that our rain storms are of a very wide extent, oftentimes over 1,000 miles in diameter, and may take their origin and bring their moisture from distances of 1,000 miles and more, the thought that man, by his puny efforts, may change their action, or modify it in any way, seems ridiculous in the extreme."[1]

Mr. Russell, says :—[2]

"The monsoons make or mar our climate. Given the monsoons full of moisture, and rain falls abundantly all over the State. If the monsoon wind is dry, it is also very strong, sending frequently and persistently strong hot nor-westers, which bring no moisture, but dry up the country like "veritable siroccos." Droughts are the result of special energy, generated in equatorial regions, and distributed over the world by the trade winds and monsoons. The source of this energy, he thinks, is outside the earth, but a full knowledge of it will not be obtained until all countries combine to trace the history of these destructive forces."

Professor Hazen has some further remarks that are pertinent in this connection, and as his paper is one of the ablest contributions to the subject that I have read, I would like to again quote him.

"It has been said that where our densest forests are found that we have the greatest precipitation. There is no way whereby we can see that such forests would have started unless favoured by rainfall, so that the presence of the forest rather indicated the earlier occurrence of practically the same rainfall as at present. Meteorologists are agreed that there has been practically no change

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[1] Hazen, *op. cit.*

[2] Report to Legislative Assembly, 31st November, 1898.

in the climate of the world since the earliest mention of such climates. . . . . . When we come down to recent times and to the records of rainfall measured in New England (U.S.A.) for more than one hundred years, or at least, before and since the forests were cut, we find a constancy in the rainfall which shows its entire independence of man's efforts. Here it should be noted that totally barren lands of any extent, in New England for example, are to be found only in imagination. Even where the forests have been cut away mercilessly there springs up a growth of sprouts which covers the ground, and answers almost the same purpose in causing rainfall (if there is any effect of that kind) as the forests. Even where land is entirely cleared of a forest we have at times the green pasture and at others still heavier crops which leave the soil anything but a sandy waste."

Professor Harrington, a learned meteorologist, also says: "The facts to hand do not prove, with entire conviction, that forests increase the rainfall. The historical method is lacking generally in the character of the data for the beginning of the comparison. Besides, where a change of rainfall has been actually shown to be coincident with a change in the forest growth it is not entirely certain that the former is due to the latter; it may have been due to what are called secular changes of the rainfall, the reasons for which lie beyond our knowledge. The geographical method is not entirely satisfactory, for reasons already mentioned. The entirely convincing method depends on observations above forests and with systems of radial stations as proposed by Dr. Lorenz Liburnau, and from these there is not a sufficient amount of published results."

IV. Clouds may Strike Against Trees and Deposit Moisture.

Trees cause a distribution of moisture from clouds, where bare surfaces do not cause precipitation, but allow the clouds to roll on. A single tree mechanically holds, for a considerable time, a large quantity of water and if this be multiplied indefinitely as in a forest, an enormous quantity

of water will be held or retarded. The effect of transpiration will be dealt with at page 228.

The following statement may be literally true, although the regularity of movement of the cloud referred to is remarkable, and with the size of the tree and the quantity of water rendered available we have nothing to do.

"In an old work, mention is made of a celebrated tree in Ferro, which is said to have furnished drinkable water to the inhabitants of the island. According to the statement, every morning the sea breeze drove a cloud towards the wonderful tree, which attracted it to its huge top, and the water flowing from its foliage uninterruptedly, drop by drop, was collected in cisterns."[1]

Mr. J. Burtt Davy in a recent work[2] speaks of the heavy summer sea fogs, drifting high overhead across the narrow stretch of bluff land, which are intercepted in their course by the trees on the summits of the ridges, or, when they lie low, roll along the broad river valleys and more numerous narrow canyons opening into the redwood forests, saturating the tree tops and by their means also the soil below, with abundant moisture.

I again quote Professor Hazen,

"There is a class of visual observations which seem to show an effect upon rainfall by the forest. Probably many have seen heavy clouds pass over a plain, but which only precipitated as they passed over a forest. Also in a hilly region it is a frequent phenomenon that fog and low-lying clouds hover near a forest, and not over an open plain. One also notes very often, in passing into a forest on a damp day, that the trees drip moisture, possibly condensed from the moisture evaporated from the damp earth underneath. Observations of this nature, however, cannot ordinarily be checked by instrumental means, but show in a

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[1] J. Croumbie Brown, *op. cit.*, p. 31.

[2] "Stock ranges of north-western California."—Bulletin U.S. Department of Agriculture, (page 12).

general way that the forest tends to conserve moisture and vapour, which in the case of the open field, would be diffused into the atmosphere."

I quote another American author:—

"An illustration of the effect of trees on moisture condensation can be seen at and around Santa Monica. All along the nine miles of country roads planted with shade trees by me, an investigator can now see green grass and verdure. Nowhere else on these plains is there anything green. The difference is due to the condensation by the trees of the evening fogs along the coast. When such occur, the trees dry the air and moisten the soil. There is a regular drip of water from the foliage and the seeds of the grasses and flowers have germinated and grown. The trees and brush on the mountain do the same thing. Anyone who has tramped through the brush on a foggy morning or after clouds have rested on the mountains, knows that the condensed moisture on the chaparral[1] will wet him more thoroughly than a sharp rain."[2]

It does not rain all along the coast of Peru for say 50 miles inland from 28° S. to the equator, yet during the months of May, June, July, August, September, every day at 2 p.m. or thereabouts, there commences to fall a very heavy mist, wetting one through if exposed to it, in a very short time. During those months all the sandy wastes are covered with a brilliant vegetation of flowers of various sorts. At the same time these plains are covered with sheep, goats, cows, llamas, alpacas, mares, etc., etc. No running streams of water are necessary, sufficient moisture being contained in the mists settling on the plants and

[1] Chaparral is the Spanish word for a thicket of low shrubs, and was used by the Spanish-Californians to designate the thickets of scrub-oak *(Quercus dumosa)* which are so noticeable a feature in the rocky ridges of this region. It is now applied promiscuously to any low, dense brush of prickly or rigid shrubs growing in similar situations, as well as to the individual species of which the mass is composed.—"Stock-ranges of North-western California," J. B. Davy, p. 31.

[2] "Forestry in California," by Abbot Kinney.

flowers. The cattle and all the animals get fat during their stay on the "Lomas" as they are called. I am indebted to Mr. Charles Ledger of "Cinchona Ledgeriana" fame, for the above particulars. He was long resident in Peru.

This deposition of moisture by means of trees is familiar to many of us in New South Wales. We have observed it in the forests covering the coastal escarpment, while the dripping of the trees from the "mountain mist" is a phenomenon very familiar to visitors to such of our mountain districts as are forest-covered.

V. Not Merely a Question of Large Trees.

When one speaks of the effects of the destruction of vegetation on the climate, it is a common error to assume that trees, forest trees, are alone referred to. As far as the Western country is concerned, the number of trees available for ringbarking has at all times been insignificant in comparison with the coastal country and Dividing Range. In other words they were not there to ringbark. But there has been much vegetation of a smaller kind, and it is believed by many that the eating out and burning over of much of this vegetation is responsible to some extent for the changed condition of the western country to-day.

The problem for New South Wales is to make the very best use of the water we receive, to keep it as long as we possibly can, and the encouragement of vegetable growth is a factor which tends to enable us to do this.

"The main forest covering of the mountains of Southern California consists of chaparral and brush. This covering holds the soil on the steep mountain sides and detains the rainfall delivery so that time is given for it to percolate into the water veins and natural reservoirs. Where these water-sheds are burned over, the importance of the forest covering is at once demonstrated. In such districts the destructive force of the floods increase. . . .

The rainfall is thus suddenly delivered to the injury of all. On the other hand, the perennial character of springs and streams is diminished or destroyed. . . . When the forest is gone on these steep Sierras, floods and torrents alternate with wide and arid wastes of waterless torrent beds."[1]

VI. Rainfall Measurements in Forests and Open Country.

"We have large areas in this and neighbouring colonies where the forest is so thick that it will not pay to clear it away. Yet these very rain-traps secure no more than the bare country, as I know by actual experiment carried on in one forest for a number of years, and in the dry time they suffer from drought just as the bare country does."[2]

"But the strongest argument adduced in the past to show the influence of forest on rainfall has existed in a comparison between rain-gauge measures in the forest and in the open field. Such records have been made for more than thirty years in France and Germany, and surely we must have here, if anywhere, a sufficient proof of a forest's influence.

"Admitting that we have perfect instruments and careful observers, there still remains a most serious doubt as to the immediate environment of each gauge and as to the possibility of a direct comparison. It is probable that no two gauges 2000 feet apart can be placed so as to catch the same amount of rain, though to all appearances the exposure is faultless in each case."[3]

Extreme caution is therefore needed in interpreting rainfall records in forests. We have also evidence of the partiality of rain showers on similar surfaces, *e.g.*, it sometimes rains in one paddock and not in an adjacent one. Professor Hazen gives instances of accurate records in forests and adjacent country by meteorologists, both in

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[1] Abbot Kinney, *op. cit.*

[2] Mr. H. C. Russell, *Sydney Morning Herald*, 1st December, 1898.

[3] Professor H. A. Hazen, *op. cit.*

France and Germany, and shows the inconclusiveness of the results. Croumbie Brown in his "Forests and Rainfall" also gives a full account of these researches, which cannot be further alluded to in detail here.

Let me however point out that the humidity of a forest is not entirely a matter of rain-gauge measurements. I think in order to thoroughly test this aspect of the question the hygrometric state of the atmosphere in various places, whether carrying forests or other vegetation and whether denuded by the hand of man or not, should be ascertained and compared for a series of years. The districts should be as numerous as possible, but we should not limit the observations to rain which can be measured in a rain-gauge. It will be found that much of the moisture which goes to assist plant growth and to modify climate is not measured by such a crude instrument as that referred to.

Those who desire further information on the subject are recommended to read the chapter "Rainfall in, above and near forests" by M. W. Harrington, at p. 106 of the work "Forest Influences" already quoted.

VII. Physiological Action of Trees—Transpiration.

Another phase of the conservation of water by trees is the question of transpiration. This is the technical word for what may be described as the perspiration of plants. The tree absorbs moisture by its roots, which is utilized to continue the functions of the plant, and a portion of it is exhaled in the form of vapour by each leaf, and passes into the atmosphere. The effect of a single tree is a very large multiple of that of a single leaf, and that of a forest is similarly greater than that of a single tree. This emission of vapour by plants is more or less fully dealt with in all works on vegetable physiology. In this way a forest has an appreciable effect on the humidity of the atmosphere, and this is one of the reasons why, on the

ground of transpiration alone, the atmosphere of a forest is moister than that immediately above the surrounding land, and it is desirable to conserve the forest growth on that account.

Botanists have made many measurements of its amount and their results are extremely varied, due partly to the fact that this function varies much naturally, and still more to the fact that experiments are generally made under conditions which are not natural to the plant. Sachs says that it is no rarity for a tolerably vigorous tobacco plant at the time of flowering, or a sunflower of the height of a man, or a gourd plant with from fifteen to twenty large leaves, to transpire from one to two pints of water on a warm summer day; and, so far as may be judged by the use of branches with the cut end in water, it may be believed that large fruit trees, oaks or poplars absorb, transport through their stems, and transpire through their leaves, ten to twenty or more gallons of water daily. It is not generally practicable to compare the transpiration with known meteorological phenomena, such as evaporation from a water surface, or from the soil, or the precipitation, but some such comparisons have been made. For instance, comparing the leaf surface to an equivalent water surface, Unger makes transpiration from the former 0·33 of the evaporation from the latter; Sachs for white poplar 0·36, the sun-flower 0·42. Comparisons have also been made between the transpiration from plants and from the evaporation from the surface over which the plants stand. Schleiden thought that the transpiration from the forest was three times that of the water surface equal to the territory covered by the forest, Schübler thought it only a quarter; and Pfaff, who studied a solitary oak in a garden, found that it varied from 0·87 to 1·58. Comparing the transpiration of plants with the evaporation of the bare

soil which would be covered by them, Hartig thought the transpiration of a forest less, Schübler found it 0·6 for the forest and 3·0 to 5·0 for the sod. Marie-Davy found it, for firs 1·18, for beeches 1·32, for sod 1·86.

The quantity of water so used is as variable as the amount of precipitation, and in fact within certain limits depends largely upon it. That is to say, a plant will transpire in proportion to the amount of water which is at its disposal. Transpiration is also dependent on the stage of development of the plant, on the nature of its leaves and the amount of its foliage, on temperature, humidity, and circulation of the air, on the intensity of the sunlight, and on temperature and structure of the soil and other meteorological conditions. Rain and dew reduce the transpiration, wind increases it. The amount of transpiration depends considerably on the thickness of the leaves, therefore the surface of the foliage is not a reliable measure, but should be compared with the weight. With so many factors to vary them, the values which may be given for the amount of transpiration of various kinds of trees, can only be approximations of its range within wide limits. (Harrington, *op. cit.*)

"All vegetation takes up a certain amount of water, a part of which is consumed in building up its body, and a still larger part returned to the atmosphere by transpiration during the growth."

The factor of dissipation having been fully discussed, it need not be further considered here, except to recall the conclusion that forest growth transpires considerably less than other kinds of vegetation.

Since this water is given off again to the atmosphere in the locality where it has fallen—thus enriching the atmospheric moisture—and is therefore only diverted temporarily for the purpose of doing duty in producing useful substance and retaining it in the locality where it has

fallen for a longer time, transpiration may even be considered as an element of conservation.

There is still tobe considered a certain amount of moisture which is retained and stored up in the body of the plant, partly as a necessary permanent constituent, partly as a temporary constituent, being evaporated when the plant dies or the wood is seasoned. The amounts thus retained vary considerably according to age, capacity for transpiration, site, soil, climate, density, slow or rapid growth, weather, seasons, and even the time of day. It is therefore almost impossible to give anything but very rough approximations, especially as also the different parts of the tree vary considerably in the amounts of water present. (Fernow, *op. cit.*)

VIII. Some Uses of Forests.

a. *To Temper Floods.*—I have dealt with this subject in a former paper,[1] hence I propose to give more cursory treatment in this place than its importance demands. I think very few men will dispute the good effects of forests mitigating the effects of downpours of rain in regard to the flow of water-courses.

"The effects of forests in retarding the flow of the rainfall after its precipitation has been established, I consider, beyond all question."[2]

"Already the rivers that rise in those regions (Northern United States), flow with diminished currents in dry seasons, and with augmented volumes of water after heavy rains. They bring down larger quantities of sediment, and the increasing obstruction to the navigation of the Hudson, which are extending themselves down the channel in proportion as the fields are encroaching on the forests, give good grounds for the fear of irreparable injury to the commerce of the important towns on the upper waters of that

[1] "The Mitigation of Floods in the Hunter River," *ante* p. 107.
[2] J. Croumbie Brown, *op. cit.*

river; unless measures are taken to prevent the expansion of the improvements, which have already been carried beyond the limits of a wise economy."[1]

Professor Fernow says:—

"The present policy of forest destruction and of allowing our waters to run to waste, not only entails the loss of their beneficial action upon plant production, but permits them to injure crops, to wash the fertile mould from the soil and even to erase and carry away the soil itself."

And again:—

"Here the comparative lengths of the affluents alone may become all important, since the simultaneous or non-simultaneous arrival of flood waters may determine the occurrence or non-occurrence of floods. As far as the forest cover is concerned in such cases, deforestation in one side of the valleys and consequent rapid discharge may become an advantage for the water to flow in the main river, by allowing its removal before the arrival of the flood waters of another affluent. In view of these considerations it would therefore, be folly to assign to the condition of the forest cover in the catchment basins an all determinative function. Nevertheless, in general the influence of favourable forest conditions in the catchment basin upon river flow cannot be doubted, although it may become practically of no account in abnormal floods. . . . In the torrent of Bourget, which had been reforested and corrected in its bed, a simple, somewhat turbulent run of water was observed, which at the overflow reached the height of 45 centimeters (18 inches) and lasted about three hours. The report thus continues :—

"The facts show the importance of the forest cover. Thanks to the dense growth planted, the flood waters, divided in numberless runs and retarded constantly in their movement over the declivities in the upper basin, arrive only successively and little by little in the main bed, instead of these formidable masses of water and

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[1] Peppercorne, *op. cit.*

débris which, rapidly agglomerated, rush into the channel; the brooks called to replace the torrent receive only pure water; flood waters flowing off gradually and made harmless by the regulation of the torrent bed and of the slopes."

b. *To conserve springs and to aid in the more even distribution of terrestrial waters.*—These subjects are intimately associated with the preceding, the necessity for the tempering of the floods being only an extreme case of the conservation and distribution of water.

"Under the forest shade the soil is in a state of perpetual increment from the humus afforded by decaying foliage and trunks and roots hold it together; the branches break the violence of the rainfall; the spongy absorbent nature of the soil enables it to retain it; and this, slowly sinking into the underlying rock, preserves the needful moisture in the soil, and becomes the source of perennial springs. But if such a mountain forest be suddenly laid low, we have not only to fear the appearance of an undergrowth prejudicial to tree reproduction, but we have to fear the total loss of the soil, which, exposed to the violence of the falling rain, and no longer held together by the tree-roots, gets washed down into the valley below, until the bared subsoil or rock is unfitted for the support of any but the scantiest herbage."[1]

And again:—

"It has been well established that forests have a most important bearing upon the conservation of rainfall; that the forest floor permits a seepage of water to the source of springs, and thus maintains their steady flow; that they hold back the precipitation that falls, especially in the form of snow, thus preventing or ameliorating the effects of dangerous freshets. There is not the slightest doubt of their great importance to the welfare of man, but all these facts do not affect the question of their influence upon precipitation."[2]

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[1] Amery, "Notes on Forestry," page 12.

[2] H. A. Hazen, *op. cit.*

"Two years' observations are insufficient to show any definite variation in the annual average of the quantity of rain. But, so far as they go, they show that at Marmato the mass of running water had diminished, in spite of the larger quantity of rain which fell. It is therefore probable that local clearings of forest land, even of very moderate extent, cause springs and rivulets to shrink and even to disappear, without the effect being ascribable to any diminution in the amount of rain that falls."[1]

"It is an almost universal and, I believe, well founded opinion, that the protection afforded by the forest against the escape of moisture from its soil by superficial flow and evaporation, insures the permanence and regularity of natural springs, not only within the limits of the woods, but at some distance beyond its borders, and thus contributes to the supply of an element essential to both animal and vegetable life. As the forests are destroyed, the springs which flowed from the woods, and, consequently, the greater water-courses fed by them, diminish both in number and volume."[2]

Some other references to various authorities incidentally touch upon the effects of forests on the flow of springs.

I will take further examples in our own State, quoting some that are of especial interest to us at this time because they are on the catchment area of the Sydney Water Supply. There are places on slopes, *e.g.*, at Cordeaux River and East Kangaloon (*e.g.*, the properties of Messrs. Brooker and Kirkland) in which there were intermittently dry creek-beds before the arrival of the white man. Since the felling of trees has taken place from the vicinity of the creek-bed, a permanent water-supply has resulted. In fact in one case in which there was no creek at all within human knowledge, the selector has had to provide himself with a small bridge.

[1] Boussingault, quoted by J. Croumbie Brown, *op. cit.*

[2] J. Croumbie Brown, *op. cit.*, page 167.

Again, the Cataract River rises on Mount Keira in densely timbered country,—the Coast Range, where there is a rainfall of say 60 inches, yet this is an intermittent stream. On the other hand, the Cordeaux River, which rises at the back of Mount Kembla, further south, is more sparsely timbered and has been cleared up to nearly the head of the river, yet it never ceases to flow. It is also in country with less average rainfall than the preceding.

Mr. Harris, the Ranger of the Catchment Area, informs me that there are two tributaries running into the Cordeaux River on its left bank, viz., Sandy Creek and Wattle Creek. The former perhaps drains a larger area than the latter. Sandy Creek is well timbered; Wattle Creek is sparsely timbered. During the present drought Sandy Creek has ceased to flow, while Wattle Creek is still running. He is emphatic in attributing this increased flow to the denudation of the timber, stating that the trees transpire or absorb the water which is dissipated into the atmosphere.

"I have found that a spring in the parish of Dulladerry, about two miles from Meranburn railway station, went dry during the drought of 1884, but has given no indication of failure during the recent dry weather. Since 1884 the country from whence it derives its water has been ringbarked. Observant, practical men asserted several years since that the spring would not go dry, as the basin of the creek in which the creek is situated is ringbarked. Their prediction has proved true."[1]

In this case it may have been that the absorption and transpiration of the water by the trees is greater than by the grass which increased in the ringbarked country. It seems like an argument in favour of cutting down forest trees to improve the moisture conditions of the country. Or it may have been that the rain ran off this particular area of country as a forest, or scattered forest, more rapidly

[1] Mr. James Anderson in *Sydney Morning Herald*, 10th January, 1889.

than when the surface was covered with grass. The question of conservation of moisture is many sided and must be considered in all its bearings in order to form just conclusions.

To say that the regular and permanent flow of the streams is owing to the felling of trees is easy, but to explain the causes is difficult. I have already stated that the natural forest growth retards the flow of the water and hence tempers floods. The continued cutting of trees may cause the flow to be regular under normal (*i.e.*, non-flood) conditions. What is the cause? Is it transpiration? I think there is still much room for research on the subject, for some of the statements appear to be absolutely contradictory at first sight.

We have very few data of practical value not only in regard to transpiration but also in regard to absorption. We have many laboratory results, but these inductively applied to a congeries of roots, or a congeries of leaves forming a forest, produce in many cases absurd results. For example, we have results when worked out which show that a gum tree absorbs and transpires incredible quantities of moisture, figures which literally make one's mouth water in this thirsty land.

Professor Fernow gives a remarkable illustration of the difficulties that surround attempts at quantitative determinations of hydrographic investigations of a watershed. For example, the amount of annual discharge of the river Rhone corresponds to a rainfall of 44 inches over the watershed, while the rainfall records themselves for a certain period give a precipitation of only 27·6 inches. Truly meteorological and kindred data require to be interpreted by experts. Professor Fernow makes the suggestive statement :—

"The water capital of the earth consists of two parts, the fixed

capital, and the circulating capital. The first is represented not only in the waters on the earth, but also by the amount of water which remains suspended in the atmosphere, being part of the original atmospheric water masses which, after the rest had fallen to the cooled earth, remained suspended and is never precipitated. The circulating water capital is that part which is evaporated from water surfaces, from the soil, from vegetation, and which, after being temporarily held by the atmosphere in quantities locally varying according to the variations in temperature, is returned again to the earth by precipitation in rain, snow, and dew. There it is evaporated again, either immediately or after having percolated through the soil and been retained for a shorter or longer time before being returned to the surface, or, without such percolation, it runs through open channels to the rivers and seas, continually returning in part into the atmosphere by evaporation. Practically, then, the total amount of water capital remains constant; only one part of it—the circulating capital—changes in varying quantities its location, and is of interest to us more with reference to its local distribution and the channels by which it becomes available for human use and vegetation than with reference to its practically unchanged total quantity."

c. *To prevent evaporation of water.*—In the Journal of the Royal Agricultural Society, N.S., Vol. II., page 110, there is a statement, by Mr. R. Orlebar, of Wellingborough, on the advantage of planting trees around ponds, in which he says,—

"It is astonishing what effect a little shade has in checking evaporation. A pond that is well shaded will hold water for weeks after one of equal dimensions, but lacking shade, will become dry."[1]

This is a matter of considerable importance to us as in most parts of the country the conservation of water is the first consideration. Officers having control of roads

[1] Brown, *op. cit*, page 55.

are usually very particular, where the road is at all damp, to cut down the trees by the side of it, in order that the sun and wind may play upon the road and dry it up. It is quite true that trees by the side of water absorb some of it during the process of growth and emit it into the atmosphere by the process of transpiration as I have already stated, but as a very general rule it would effect economy in water if dams and other receptacles for water were surrounded by a thick belt of trees. The question of diminution of evaporation should always be considered in cutting down trees from the vicinity of any stagnant or flowing water in this country.

The matter of shade is stated in another way when we draw attention to the fact that clumps of trees or forests prevent desiccation of the ground,—the forest floor.

d. *To give shelter for stock, crops, etc.*—This is a mechanical action of forests and their value in that respect is so evident as not to be open to argument.

Professor M. W. Harrington (*op. cit.*, pages 23-4) says that the forest is to be considered, in its effects on climate and weather, as a special form of surface covering. Its effects are of the same order as those produced by a covering of sand, or sod, or water, but the forest effect has some peculiar features which are due to the fact that the covering is elevated to some extent above the soil. This imparts to the soil in some degree the climatic characteristics due to a topographical elevation, and also causes a series of wind-break effects which are not found with the other forms of surface covering. On account of this distinctive feature, the problem of forest climatology separates into two problems, which must be considered each by itself. The one relates to the climate of the interior of the forest, and the other to the effects of the forest on the climate of the country around it. The two are quite different; the

first is of relatively little importance except as it relates to the second. It is the second which is of interest and importance so far as relates to the suitability of a climate for residence and agriculture. The same authority at page 118 (chapter "Forests, wind and storms") speaks at greater length on the wind-break question.

e. *The leaves of forest trees afford manure and mulch.*—This is less evident in the dry country than in the well watered coast belt and coastal mountain ranges, and is of less importance in Australia where trees are mainly non-deciduous as regards their leaves. But the matter is one of extent rather than principle, for we have débris of all kinds from living trees, consisting not only of leaves, but of flowers and fruit, limbs and trees, and, as regards our Eucalyptus forests, a large percentage of naturally shed foliaceous bark. All this serves as a manure and mulch to the forest floor and thus the evaporation of the moisture is diminished.

Mr. Marsh speaks of the ever renewed and increasing vegetable mould as a perpetual *mulch*, and in reference to the humidity of forest soil he cites the following passage from *Etudes sur l'Economie Forestière*, by Jules Clave:—

"Why go so far for the proof of a phenomenon which is repeated every day under our own eyes, and of which every Parisian may convince himself without venturing beyond the Bois de Bologne, or the Forest of Meudon? Let him after a few rainy days pass along the Chevreuse Road, which is bordered on the right by the wood, and on the left by cultivated fields. The fall of water, and the continuance of the rain, have been the same on both sides; but the ditch on the side of the forest will remain filled with water, proceeding from infiltration through the wooded soil, long after the other, contiguous to the open ground, has performed its office of drainage and become dry. The ditch on the left will have discharged in a few hours a quantity of water which the ditch on

the right requires several days to receive and carry down to the valley, and but for this drainage into the ditch the water might have remained there for an indefinitely longer time."

Speaking of the forest floor, irrespective of a leaf-mulch surface, Professor Harrington quotes Fesca to the effect that the downward movement proceeds quickest in a dry dust, only slowly in clay soils, the same amount of water being drained through the former in one hour which took two days to drain through the latter, and emphasises the point that the surface conditions of the soil of a watershed are the only controllable factors in the problem.

* * *

I now submit the whole subject to the consideration of members of the Society. The matter of forest meteorology and the questions that crop out of it present many puzzling problems to us in Australia, and some of them have as yet baffled the meteorologists of long settled countries. A proper understanding of the principles which underlie the relations of forests and moisture is of interest to us in two special ways, first as regards the water supply of a large city (Sydney), and secondly as regards the distribution and conservation of moisture over the whole of the State. Reasonable expenditure for research would be justifiable if we could be thereby placed in a position to deal less empirically with the rainfall we receive, and to know how to conserve it more wisely than we do at present. A certain quantity of rain falls upon New South Wales; do we take care that it will do us most good and remain with us, benefitting us as long as possible? Many public questions that loom large in the public eye should really claim less of our attention than this.

METEORIC DUSTS, NEW SOUTH WALES.

By Prof. A. LIVERSIDGE, LL.D, F.R.S., University of Sydney.

[*Read before the Royal Society of N. S. Wales, September 3, 1902.*]

Introductory.—The term meteoric dust is used because it is commonly applied to the materials forming the subject of this paper; it is not, however, intended to state that the dusts are necessarily wholly of cosmic or extra terrestrial origin. The specimens described and exhibited were from Moruya, (fell on Dec. 15th, 1880); from Uralla, (fell on Dec. 14th, 1882); from near Broken Hill, (fell 1896); from Menindie (fell June 17th, 1899); and Pambula, (fell Oct. 5th, 1899). Dust from the roof-beams and mud from a covered cistern at the University and from the roof of the Observatory, Sydney, were collected in 1882.

All the dusts are of a reddish colour except those from the University and Observatory, which are grey. The red dusts are mainly siliceous and argillaceous, and look as if they had come from dried up water-holes; they contain a variety of organic and mineral matters such as might be expected from such sources, and in addition magnetite and metallic iron, containing cobalt and nickel.

The University and Observatory dusts also yielded magnetite and metallic iron containing cobalt and nickel.

Meteoric Dust, Moruya, N. S. Wales.—The specimen of meteoric dust forming the subject of this note was forwarded to me by Mr. H. C. Russell, Government Astronomer, who informs me that it fell on December 15th, 1880 at Moruya, a small town in New South Wales, 198 miles south of Sydney and distant 5 miles from the sea.

The specimen consists of a pale clay- or snuff-coloured powder, of uniform tint and appearance; for the most part

it is composed of an impalpable dust, but on carefully flattening it out under a spatula and on rubbing it between the finger and thumb a few coarser gritty particles can be felt. To separate the finer material from the coarser particles, a portion of the dust was placed in a tall conical precipitating glass, and subjected to the action of a stream of water carried down by means of a glass tube to the narrow bottom of the glass. The residue left in the glass was found to be made up of grains of quartzose sand and white particles, the latter dissolving readily in dilute acids with effervescence; some of these were grains of amorphous calcium carbonate, but a few of the larger were readily recognised under the microscope as fragments of shells, but whether of fresh water or marine mollusca could not be decided, as they are much abraded; in addition there are some rather larger soft black particles which readily flatten out under the spatula to an unctuous black mass; when ignited on platinum foil these black particles slowly burn away with but slight incandescence, like charcoal; but emit a strong empyreumatic odour and leave a bulky white ash, some of them when crushed and examined under the microscope present a cellular structure very similar to that of wood, but rather obscure; others, however, are devoid of all recognisable structure.

The more or less complete obliteration of the original structure is due to the fact that the wood has undergone considerable change, either by natural decay or by the effects of fire. The woody matter does not, however, present the appearance of ordinary charcoal such as might have been recently derived from house or bush fires; it has evidently been long subjected to the action of water, and it is highly probable that some of it is not charcoal but simply fragments of water logged woody matter, black from decay, common in rivers and fresh water lakes and

ponds. Intermixed with the other substances there is also a certain proportion of less decomposed vegetable matter in a flocculent state, and the remains of two or three small beetles were present—all such substances were removed as completely as possible before making the chemical examination; some minute particles of a yellowish mica are scattered through the specimen; mica is common in many muds, especially in those deposited by water running over granite, gneiss or similar rocks; the rock about Moruya is granite, hence the presence of the mica can be accounted for locally.

As it was thought that particles of metallic iron might be present, a magnet covered with a moveable paper cap, was repeatedly drawn through the powder when a few scaly fragments of the metal with jagged edges were obtained—the fragments were found to be malleable, but not highly so, since they rather readily split up under the pestle when crushed in an agate mortar; they also became burnished and acquired the usual colour and metallic lustre of iron. They at once reduce a solution of sulphate of copper and become coated with metallic copper, apparently just as readily as ordinary iron; they also afford the usual reactions for iron on the application of the wet tests; cobalt is present in sufficient proportion to give the usual blue colour with the borax bead, and I believe that nickel is also present but the quantity of metal was not sufficient to satisfactorily determine this, neither did it afford conclusive evidence as to the presence of sulphur and phosphorus.

The total quantity of magnetic matter separable by the magnet out of 27·524 grammes of the dust (the whole of that at my disposal) amounted to but ·009 gramme; the largest fragment weighed ·0019 gramme.

Externally the iron particles are covered with a thin coating of ordinary red rust, the hydrated sesquioxide of

iron, and present no traces of fusion nor of the skin of magnetic oxide, usually present on the surface of large masses of meteoric iron.

The minute fused or round globules of iron met with by Mr. Murray (now Sir John Murray, K.C.B.) in the dredgings obtained by H.M.S. Exploring Vessel "*Challenger*," were specially sought for but without success.[1]

On heating the dust in a glass tube it readily blackens, gives off water with a strongly marked alkaline reaction and emits an empyreumatic odour, hence there is a notable proportion of nitrogenous organic matter present, and this is confirmed by its behaviour when heated on platinum foil, for it at once blackens, and the scattered particles of organic matter ignite and are seen as glowing points or sparks running over its surface; at the same time a well marked nitrogenous odour is evolved. After burning off the whole of the combustible matter the residue is of a reddish clay-brown colour not materially different from that of the original substance. Apart from the larger woody particles, the organic matter must be very uniformly distributed since the dust appears on ignition to blacken equally throughout.

Under the microscope the dust is seen to be almost entirely composed of small particles between $\frac{1}{2000}$th and the $\frac{1}{500}$th of an inch in diameter, or ·01 to ·02 mm., a few of the coarser grains of sand being about $\frac{1}{25}$th of an inch, or 1 mm. Very few of them are quite opaque, the larger grains are colourless and transparent but most of the smaller particles transmit a yellowish-brown colour; with but very few exceptions the particles are rounded or subangular, as if wind or water worn, and with no recognisable traces of igneous fusion. Some diatom frustules are sparingly scattered through the dust, these strongly

[1] Proc. Royal Soc., Edinburgh, 1876, p. 258.

resemble, and may be identical with *Diatoma vulgare* and *Surirella constricta*, a few siliceous spicules, something like sponge spicules are also present; these together with the diatoms are rather more readily detected after treating the dust with nitric acid. A few vegetable fibres, including some filaments of cotton, together with vegetable spores are also revealed by the microscope. There are also a few scattered minute black non-magnetic particles which are probably chrome iron, but the quantity is insufficient for me to satisfy myself on this point.

A qualitative examination yielded me the following results:—the presence of organic matter, water both hygroscopic and combined, silica both as free quartz and in combination with bases, mainly with alumina in the form of clay; iron, metallic and in combination as oxide, cobalt, and probably nickel, a trace of copper, manganese, lime, magnesia, potash, soda and small quantities of hydrochloric, sulphuric, phosphoric and carbonic acids. The dust appears to consist mainly of finely divided clay mixed with other substances.

The hydrochloric acid, as soluble chlorides, is present in rather greater quantity than either the sulphuric or carbonic acids; there is but a trace of phosphoric acid.

An examination with the spectroscope failed to reveal the presence of any rare or unusual element in either the soluble or insoluble portion.

A quantitative examination gave the following results:

Moisture at 100°	5·400
Loss on ignition	9·700
Silica	58·020
Alumina	17·184
Ferrous oxide	1·214
Ferric oxide	4·237
Lime	2·270
Soda	traces
Potash	trace
Undetermined	1·975
	100,000

As the result of the examination, I think that part of the dust is of meteoric origin, but there is also no doubt that the main bulk of it is from terrestrial sources. I do not think it is of volcanic origin, since it does not present the characters of a volcanic ash; there are but few traces of augite or other crystals such as we might reasonably expect to be present in a windborne volcanic dust, further the large proportion of combustible matter present is against this idea. Most of it has doubtless been derived from the deposits left by dried up fresh water pools, lakes or watercourses, for with the exception of the fragments of shells, the dust is quite unlike a sea shore deposit; the shells and diatoms may be either of fresh water or marine origin, the sponge spicules, however, point to the latter source, but these together with other portions of the dust may not have been deposited at the same time. More light would probably be thrown upon the question could specimens of the mud which fell at the same time on board ships off the coast be submitted to an examination.

I do not suppose that much if any of the combustible matter is of meteoric origin although considerable amounts of carbonaceous and bituminous substances have been met with in several meteorites, *e.g.* the Bokkeveld, Kaba and other meteorites; the nickel-iron meteorites found at Bingera, N.S.W. and elsewhere, contain carbon; in fact carbon is commonly present in metallic meteorites. But I think the metallic portion is of meteoric origin and perhaps part of the earthy matter also. The probability of the metallic portion being of cosmic or meteoric origin is borne out by the peculiar appearance of the iron, its imperfect malleability, resembling in these respects certain other irons of undoubted meteoric origin; by the presence of cobalt and the probable presence of nickel; copper was found in the hydrochloric acid solution of the

dust, and it may or may not have been present in the metallic iron also; the quantity of metal extracted by the magnet and separately examined was too minute to determine this. Copper has been detected in many meteorites and in several specimens of meteoric dust, and it was found together with metallic iron, cobalt and nickel by Mr. J. Y. Buchanan, M.A., F.R.S., chemist and physicist to the "Challenger" expedition, in the clays, manganese nodules and cosmic dust which were dredged up.[1]

A specimen of dust which fell on board a ship in the Atlantic was found by Gibbs to contain copper; after driving off 18·53% of water the composition was found to be as follows:—

Silica	45·58
Alumina	20·55
Ferric oxide	9·39
Manganic oxide	4·22
Calcic carbonate	11·77
Magnesia	2·21
Potash	3·64
Soda	2·33
Cupric oxide	·31
	100·00[2]

Mr. G. Tissandier[1] states that he found the dust which he collected from one of the towers of Notre Dame in Paris, into which no one had entered for years, to closely resemble that which he detached by friction from meteorites. He found metallic iron, probably of extra-terrestrial origin, in all the samples examined. An analysis of one gave him the following results:—

Dust from the tower of Notre Dame, Paris.

Organic matter rich in carbon	32·265
Soluble in water, chlorides and sulphates of the alkalies and alkaline earths, ammonium nitrate	9·220

[1] Proc. Royal Soc., 1876, p. 531.
[2] Watts' Dictionary of Chemistry, Vol. III., p. 982.

Iron sesquioxide	6·120
Calcium carbonate	15·940
Magnesium carbonate, traces of alumina, phosphates, etc...	2·121
Insoluble in hydrochloric acid	34·344
	100·010

In further papers[2] M. Tissandier gives additional information upon some specimens of atmospheric dust and especially upon those which fell on the Canary Islands, Feb. 7th, 1863, at Syracuse and in Italy on May 10th, 1872, and at Boulogne sur Mer, October 9th, 1876. Drawings are given to show the differences between such meteoric dust and the sands of the English channel and of the desert of Sahara. In the same volume, p. 364, there is also a note, by Mr. Phipson of London, upon the presence of metallic iron in atmospheric dust.

In an account of his expedition to Greenland in 1870, Prof. A. E. Nordenskjöld states[3] that at the bottom of the holes in the ice he found a grey powder, to which he gave the name of cryoconite (κρύος ice and κόνις dust); he found it on inland ice as well as on the shore ice; Nordenskjöld concluded that it was not derived from the disintegration of the rocks in the district but from meteoric sources, especially as it contains particles of metallic iron bearing cobalt, copper and probably nickel. Prof. Nordenskjöld describes it as occurring in layers some millimetres thick and often conglomerated into small loose balls, and under the microscope as being principally made up of white angular transparent particles intermixed with vegetable fragments as well as particles of what appears to be felspar and augite.

Dr. G. Lindström obtained the following analytical results from a sample:—

[1] Comptes rendus, LXXXIII., p. 821. [2] *Ibid.*, LXXXIII., 1876, pp. 76, 1184.
[3] Geological Magazine, 1872, p. 355.

Cryoconite.

Silica	62·25
Alumina	14·93
Iron sesquioxide	·74
Iron protoxide	4·64
Manganese protoxide	·07
Lime	5·09
Magnesia	3·00
Potash	2·02
Soda	4·01
Phosphoric acid	·11
Chlorine	·06
Water, hygroscopic, at 100° C.	·34
Water and organic matter at a red heat...	2·86
	100·12

When long digested with strong sulphuric acid 7·73% dissolved and 16·46% when treated with strong hydrochloric acid. The organic matter seems to have been mainly due to the presence of various minute algæ. Particles of metallic iron have on several occasions been found in snow collected in places where there was no possibility of the iron having been derived from surrounding habitations.

In December 1871 Nordenskjöld collected some snow near Stockholm after five or six days consecutive fall, which on melting left a black soot-like residue containing metallic particles; to remove any possibility of doubt, Dr. Karl Nordenskjöld collected snow from off the ice of the Rautajerwi on March 13th, 1872, at Evoia in Finland,[1] separated by a thick forest from any houses. The residue left on melting was soot-like in appearance, and under the microscope was seen to contain black carbonaceous particles, with yellowish-white granules and black magnetic grains, but the quantity was insufficient to determine the presence of cobalt and nickel. But snow collected by the Arctic expedition on August 8th, 1872, on the drift ice in Lat. 80° N.

[1] Dr. Walter Flight, History of Meteorites, Geological Magazine, 1875, p. 157.

and Long. 30° E., yielded particles of metallic iron; also on September 2nd, in Lat. 80° N. and Long. 15° E., freshly fallen snow collected from the icefield yielded from 0·1 to 1·0 milligram of black magnetic particles to the cubic metre of snow; iron, cobalt and phosphorus were detected and probably nickel was present also; the portion insoluble in acid contained fragments of diatoms and minute transparent angular particles.

Dr. Moss speaks of similar dust[1]:—"Occasionally deposits of atmospheric dust were to be met with throughout the stratified ice sometimes scattered in very minute points which when examined proved to be air cells coated with the impalpable dust, sometimes occurring in comparatively conspicuous quantities in lines cutting the stratification and marking what had once been the bottom of a superglacial lake. Similar dust was to be found on the present surface of the floes occasionally greatly magnified in appearance by the growth amongst it of an alga *(Nostoc aureum)*. The dust often occurred in little granules so that in mass it formed an oolite. . . . All the specimens of ice dust obtained by me from the floe bergs are undoubtedly the air carried débris of crystalline rock not traceable to the neighbouring shore."

On February 26, 1883, a fine dust was discovered in the snow in Trondhjem Amt in North Norway. Dr. Reusch of the Mineralogical Faculty of the Christiana University found that it was not of volcanic origin as had been imagined, but that it consisted of fine particles of quartz sand, hornblende and talc, mixed with very fine particles of vegetable matter. The dust must have been carried a very long distance, the whole of the country having been for months covered with deep snow. The wind blew strongly from N.N.W.

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[1] Voyage to the Polar Sea, in H.M.S. "*Alert and Discovery*," Capt. Sir G. Nares, Vol. II., p. 61.

In 1873, Prof. Nordenskjöld obtained rounded grains of metallic iron from hail which fell in Stockholm, other observers had done the same as far back as 1821; Cozari had in 1834 shown the presence of nickel in the iron brought down by hail.

Dr. Henry Rink, writing from Christiana, Norway, ("*Nature*," Dec. 13, 1883) draws attention to the fact that the ice of icebergs which are made up of ancient snows ought to yield large quantities of Nordenskjöld's cosmic dust, although he had never observed its presence in such ice.

Reichenbach found traces of cobalt and nickel in the soil from the Lahisberg in Austria, from the Haindelberg, Kallenberg and Dreymarksteinberg, and nickel in the soil of the Marchfeld Plain;[1] the hills consist of sandstone and limestone and are free from mineral veins. Haidinger suggested that impoverished soils when allowed to lie fallow acquire a fresh supply of phosphorus from such meteoric dust.

In the report for 1882 of the Committee of the British Association appointed for the purpose of investigating the practicability of collecting and identifying meteoric dust etc., drawn up by Prof. Schuster, it is stated that the dust falls frequently observed in the Atlantic, the southern parts of Italy, and sometimes in the Red Sea, were at one time supposed to be of meteoric origin, but it has now been conclusively proved that the dust has its origin in the sandy deserts of northern Africa, whence it is carried by the winds often through considerable distances, the grosser particles falling down first, so that ultimately only the finest remain in suspension. Although these dust storms are of terrestrial origin, yet they carry magnetic and other particles which are of meteoric origin.[2]

[1] Dr. Flight, Geological Magazine, 1875, p. 162.

[2] See Tissandier's Les poussières de l' air, Paris 1877.

Amongst the magnetic particles found in the dust are some which are perfectly spherical, these have been found in the snow of Mount Blanc at a height of nearly 9,000 ft. and in the dust collected at various other places. The spherical particles have evidently been fused—no similar ones have ever been found in volcanic dust; the smoke from factory chimneys does contain similar particles, but such contain neither nickel nor cobalt, whereas Tissandier found both these metals in the magnetic particles collected at the Observatory of Saint Marie-du-Mont. "We are therefore driven to assume a cosmic origin to these particles."

Prof. Schuster examined the sand from the desert near the Great Pyramids and found magnetic particles present in the proportion of 1 in 144,000. Most were angular and evidently derived from magnetic rocks; but with them were also some perfect spheres of iron, similar to those described by Tissandier, and about ·2 to ·1 millimetre in diameter. Prof. Schuster naturally assumes that these spherical particles have been derived from the fused surfaces of meteorites in their passage through the atmosphere. He accounts for their nonoxidized condition partly by the fact that nickel iron alloys are less readily oxidized than iron, also that the fusion and separation from the meteorites probably took place in the upper regions of the atmosphere where the amount of oxygen is exceedingly small; at a height of only 200 kilometres the percentage of oxygen in the air is only about 0·8. He then refers to the presence of an unknown gas in the atmosphere indicated by a green line shown in the Aurora borealis spectrum—he assumes that this gas must have a very low density—supposing that it be as light as hydrogen, and that at the surface of the earth its quantity per cubic centimetre is only the one millionth part of the oxygen present in the same space, it

would certainly escape all our methods of analysis. (1882). At a height of 200 kilometres it must exceed the oxygen in the proportion of 170,000 to 1, that is to say, at that height the atmosphere would practically contain no oxygen. . . . Even if there are only minute quantities of free hydrogen on the surface of the earth, it may be in preponderating proportion in the upper regions.

Tissandier has shown how by burning iron wire in oxygen we may often obtain iron spherules of exactly the same nature as those floating in our atmosphere.

"I have obtained similar spherules by using an iron file as one pole of a dynamo machine and passing the file over a copper wire connected with the other pole. The sparks consist chiefly of iron globules like those to which Tissandier attributes a meteoric origin, there are also spongy metallic masses, which present exactly the same appearance as the metallic iron found in the Sahara desert. The reason why they did not oxidize is no doubt due to the fact that a layer which were oxidized used up the oxygen in the neighbourhood of the few particles which escaped."

In 1883 the above Committee reported that three specimens of solid matter from snow and ice of the Himalayas were collected and examined. One from the Gamukdori Pass (lat. 35° 5', long. 74° 13') 13,400 ft., and two from the Shokari Pass (lat. 35°, long. 74° 38') 14,700 ft. There is no human habitation near either of these places. The residue amounted to ·1 gramme for the 25 cubic feet of snow boiled down in each case. All three specimens contained (1) spherical particles of magnetic oxide of iron, (2) small particles of metallic iron. These probably are of meteoric origin.

From the foregoing evidence it is extremely probable that, as suggested by Haidinger, Reichenbach and others, at all times and in all parts of the world there is a constant

although imperceptible rain of such meteoric dust gently descending upon the earth's surface, the amount undergoing considerable variation, at times being much greater than at others, and from all accounts the fall in the month of November is the most abundant. This meteoric dust is apparently of the same general nature, and is probably derived from the same sources as the larger masses known as meteorites.

Roof Dust, collected from the beams under the roof of the University, February 24th, 1882. The proportion of magnetic material separated from one lot of this dust was 1·3%, another lot gave 1·7%. Most of it acquired a metallic lustre when ground in the mortar, some of this was fused with caustic soda and the metallic residue was found to contain cobalt and nickel.

Mud from a Cistern.—Collected March 3rd, 1882, from a rain-water cistern (open) under the roof of the University building. When dried it yielded a grey coloured powder, containing sand grains, vegetable fibres, etc. The magnetic portion was fused with caustic soda to separate the iron oxides and entangled matters; the metallic portion contained traces of cobalt, but the indications for nickel were not satisfactory. The cobalt was present in less quantity in this than in the other roof dusts.

Roof Dust.—In March 1882, Mr. Russell, Government Astronomer, collected for me some dust from the roof of the Sydney Observatory. From 493 grams of this the magnet extracted 48·5 grams, or roughly 9·8%; but as this evidently contained much entangled non-magnetic matter it was boiled with caustic soda and repeatedly extracted with a magnet under the soda solution. The proportion of magnetic matter to the original dust was then found to be only 1·5%. Under the microscope it had the appearance of Fe_3O_4, but with it were some lustrous steely looking

flakes. The magnetic material was found to contain both cobalt and nickel.

The comparatively large quantity of magnetic matter in the three Sydney dusts is probably due to the lighter materials having been gradually removed; *i.e.*, the two dusts had been subjected to a process of vanning by air currents and the mud had been concentrated by the water flowing in and out of the cistern.

These dusts collected in Sydney confirm the results obtained by M. Tissandier and others; it was thought sufficient to ascertain the presence of cobalt and nickel. The quantitative analyses were not undertaken as they would have occupied a great deal of time and would have afforded but very little more information.

Meteoric Dust from Uralla, collected by Mr. Cleghorne, December 14th, 1883. A fine reddish dust with some angular grains; most are clear and colourless, but some are yellow or red. Like the other red dusts it contains granules of concretionary calcium carbonate, which dissolve with effervescence in acetic acid, also particles of charcoal or decayed vegetable matter. The average size of the grains is from ·01 to ·02 mm.

Analysis.

Moisture at 100°	4·25
Silica	70·60
Iron sesquioxide	4·66
Alumina	18·74
Lime	·70
Undetermined...	1·05
	100·00

Mr. Cleghorne in writing from Uralla on December 14th 1883, says, "I enclose herewith a sample of dust which fell in this neighbourhood yesterday (Thursday) morning.

About 5 o'clock on Wednesday evening we had a sudden and severe thunder storm with much rain and some hail; the evening was clear moonlight, but during the night we had several thunder showers especially towards morning—from early morning to about 11 a.m. there was a very singular yellow coloured fog, all vegetation was sprinkled with fine yellow dust, it could be easily gathered from iron roofs, but it appears to have fallen before the showers of rain in the morning as it had been washed into the gutters of the roofing, and partially washed from the leaves, some samples of which I also enclose. I have not yet been able to learn how far this unusual occurrence extended."

The foregoing part of this paper, except the quantitative analyses, was written about 20 years ago, but put by pending the completion of the analyses; since then other samples of atmospheric dust have come into my possession and the results of their examination are now given.

* * *

Meteoric Dust from the Barrier Range near Broken Hill. Collected by Mr. C. W. Lloyd in 1896. Of a reddish colour, rather coarser in grain than the dusts from Menindie, Moruya, etc. The average size of the particles is ·07 mm. or $\frac{3}{1000}$ths inch. It appears to be made up principally of water worn quartz grains stained with iron oxide, with some charcoal or carbonaceous fragments, also calcareous particles (concretions and fragments of shells) and a few black non-magnetic mineral fragments.

Analysis.

Moisture at 100°	2·30
Silica	79·10
Iron sesquioxide	2·97
Alumina	10·58
Lime	2·00
Magnesia	traces
Loss on ignition	3·00
	99·95

Meteoric Dust, Pambula.—This sample was collected by Mr. H. Forde, on October 5th, 1899, who states that it fell all over the township of Pambula (land district of Eden), and bore the appearance of a thick red fog. This dust is an extremely fine and impalpable powder of a pale brownish tint. The average size of the particles is less than ·01 mm. As it apparently does not differ materially from the others, it has not been analysed.

Meteoric Dust from Menindie.—This specimen was forwarded to me by Mr. H. C. Russell, the Government Astronomer, on November 23rd, 1899, who stated that it had been collected by a friend during a recent red dust rain storm, who took great care to get it pure; on drying (under cover to keep the ordinary dust out of it) it split up into pieces and curled up like a dried clay. Of a reddish colour; under the microscope it appears to be composed principally of rounded quartz grains some of which are reddish from a film of iron oxide. The average size of the particles is ·25 mm. or $\frac{1}{100}$th inch. Mixed with the dust are some small pieces of calcium carbonate (concretions and fragments of shells) also some fragments of soft black readily combustible carbonaceous material, which may be water-logged charcoal, from bush fires or decayed wood; there are also a few particles of black mineral matter, probably chromite, but not yet examined.

Analysis.

Moisture at 100°	0·85	
Loss on ignition	2·20	
Silica	89·15	
Iron	1·06	
Alumina	6·39	
Lime	·80	= 1·43 $CaCO_3$.
Magnesia	traces	
Alkalis	traces	
	100·45	

The following from Victoria is added for comparison:—

"*Red Rain*" *Dust*—Some of this dust was collected at Moonee Ponds near Melbourne, from a shower which fell, on December 27th, 1896, over Melbourne and a considerable area in Victoria, and was examined by Mr. T. Steel, F.C.S.[1] He regarded it as a sample of ordinary surface soil, derived from the weathering of volcanic rocks; it contained diatoms etc., such as are usually found in fresh water deposits.

Dried at 110°. Moisture in air-dried sample = 6·09

Loss on ignition	10·70
Sand, insoluble and undetermined ...	66·23
Alumina	15·16
Soluble silica...	·75
Ferric oxide	4·68
Ferrous oxide	·50
Lime	1·36
Sulphur trioxide ... ... — ...	·62
	100·00

For the sake of comparison, the following analyses of dusts of undoubted volcanic origin are added, it will be seen at once that the atmospheric or so called meteoric dust is very different in composition. Under the microscope the differences are still more strongly marked.

Krakatoa ashes, collected at Batavia. Analysed by A. Sauer (Jahrb. f. Min., 1884).

SiO_2	63·30
TiO_2	1·08
Al_2O_3	14·52
Fe_2O_3 / FeO	5·82
CaO	4·00
MgO	1·66
MnO	·23
Na_2O	5·14
K_2O	1·43
Loss on ignition	2·17
Total ...	99·35

[1] Report of the Aust. Assoc. for Advt. Science, Sydney, 1898.

Volcanic Dust from Mount Peleé, Martinque, collected from the deck of the s.s. "*Roddam*," the only ship which escaped from St. Pierre.[1] Dried at 105°:

Silica	53·40
Alumina	21·00
Iron sesquioxide	9·50
Lime	9·70
Magnesia	2·00
Na_2O	2·33
K_2O	·85
SO_3	·90
P_2O_5	·25
	99·93

Volcanic Dust, Barbadoes.[2] From the recent eruption, the ash consists principally of a plagioclase felspar allied to labradorite, hypersthene, monoclinic augite and magnetite. The following analysis was made by Dr. Pollard.

SiO_2	52·81	MgO	5·19
TiO_2	·95	K_2O	·60
Al_2O_3	18·79	Na_2O	3·23
Fe_2O_3	3·28	P_2O_5	·15
FeO	4·58	SO_3	·33
NnO	·28	Cl...	·14
(CoNi)O	·07	H_2O (105°) ...	·20
CaO	9·58	H_2O (above 105)	·17
			100·35

The following hitherto unpublished accounts of falls of meteoric dust and dust fogs in New South Wales are, except the first, selected from a large number kindly placed at my disposal by Mr. H. C. Russell, B.A., C.M.G., F.R.S., Government Astronomer; they are of interest as showing the conditions under which some of the dusts were deposited.

[1] Chemical News, June 13, 1902.

[2] Geol. Soc., May 25, 1902. "Nature," 5th June, 1902.

One of the earliest accounts of dust storms in Australia is given by Strelecki in his "New South Wales and Van Diemen's Land," published in 1845, he says :—

"In sailing from New Zealand to New South Wales in the "*Justine*," I was prevented making the harbour of Port Jackson for two successive days by the violence of the hot wind. The distance from the shore, on the parallel of Sydney, was sixty miles, and the heat exceeded 90°. The lee sails and reefs of the "*Justine*" were covered with a quantity of impalpable dust, which was at first mistaken for ashes, but, on examination proved to be sand, containing one-fourth of aluminous and three-fourths of siliceous and metallic matter. Those who shape their course to the East Indies, by way of Cape Verd Islands, may have seen the same effect produced by the north-east African hot wind."

The following account was addressed to Mr. Russell :—

"Times Office, Murrurundi, Oct. 21st, 1876.

So far as I have been able to ascertain, the dry fog was first seen in the vicinity of Tamworth, at about sunrise on the morning of the 12th instant. In the various weather notices of different journals published north or west of that town, no mention is made of the phenomenon, such as would be expected had its appearance been observed in the districts they represent. The *Tamworth News* refers to it as obscuring the horizon from north-east to south-west, and as being the result of the refraction of the solar rays on passing through the depressed exhalations from the moistened earth. In this neighbourhood the conditions under which the fog appeared were quite different, its direction being rather from north-west to south-east, and its existence altogether independent of "moistened earth," the preceding night having been too mild in temperature to produce a very copious fall of dew. With these exceptions the accounts coincide in the general representation of the event already furnished.

"Its appearance and disappearance were alike sudden, considering the immense extent of country it appears to have covered, and its rate of progress was exceedingly rapid. At half-past five a.m.

on Thursday, the valley of the Page was as clear as usual on fine mornings, but on the ranges a peculiar dense mist, in colour precisely like a dust-cloud, was seen advancing quickly towards the town of Murrurundi. At 6 o'clock the whole of the valley with the town and the surrounding mountains were enveloped in the murky haze, the atmosphere became oppressive as though a heavy thunderstorm were at hand, and the sun was so obscured that it could be viewed without the slightest inconvenience by the naked eye. No disagreeable odour accompanied the fog, but it caused a sensation similar to that experienced during the first downpour of rain upon a dusty surface, that oppressiveness to the senses generally that a continued fall of rain would be likely to relieve. In fact, had it not been for the strangely impalpable nature of the fog it would have been considered as an extraordinary diffusion of dust in the atmosphere, consequent upon strong winds. No inconvenience was occasioned to the eyes, the only discomfort being the comparative sultriness of the morning and the sense of oppression experienced. No dust was left by the fog, nor the slightest moisture; it remained for many hours a perfectly dry, dense, dusty looking mist enwrapping every object in obscurity for many miles around. Shortly after half-past eight a.m. it left the Page valley, and proceeded towards the south, driven before the wind which rushed along the passage between the mountains with great force. The general direction of the wind was nearly direct from west to east, but as usual in the valley its course locally was determined by the position of the mountains, and the fog in the lowest lands was driven off to the south at the time already mentioned, while a portion of it lingered about the hills until nearly midday; at the head of the Page, I believe, it was discernible in the afternoon.

"At Scone, twenty-five miles south of Murrurundi, the fog made its appearance shortly before 8 a.m., while Murrurundi was still enveloped in its mist. A gentleman resident in this colony for upwards of thirty years, and a very shrewd observer of the weather, happened to travel from Murrurundi to Scone during the continu-

ance of the fog, and he states that he was surrounded by it the whole way. He started on the journey about an hour after the fog made its appearance here, and his impression was that the mist was travelling at a rate of more than fifteen miles an hour. After leaving the valley of the Page the wind was found to be blowing stiffly from the west, but the fog remained at Scone until nearly midday, when it gradually cleared off.

"The manner of its disappearance from Murrurundi was somewhat sudden, and would give the impression that it was carried by the wind over the country at a considerable speed. But the fact of it having remained amongst the mountains so much longer, leads me to think that it was driven out of the valley as from a narrow passage by the increased force of the wind when compressed within the limits of the pass. The occurrence of winds in this part of different directions and force from those in more open country is too common to need further mention, and it is tolerably certain that in the open country the fog was not so visibly and directly influenced by the wind as it appeared to be at Murrurundi. It should be mentioned that the wind was not noticed until some time after the fog made its appearance; the air was at first still, heavy, and oppressive, but afterwards the wind rose quickly, with frequent gusts, which swept great quantities of dust along the main road, giving colour to the supposition of some persons that a similar wind had blown during the earlier part of the morning, raising clouds of dust, the finer portion of which were still being carried by upper currents of wind across the country. But this is only one of many explanations invented for the occasion, and without any knowledge of the extent of the fog; allusion to some others more distant from reason and experience is made in one or other of the extracts enclosed.

"At Singleton the fog appears to have been witnessed at seven o'clock, about half an hour later than at Murrurundi, while at Scone, nearly half way between, it would appear to have not been observed until a later hour than either—between half-past seven and eight o'clock. If I remember rightly, its appearance at the

Paterson was still later, and no record of its having been observed further south or east is procurable here. The Maitland and Newcastle papers make no editorial comment upon it, nor with regard to Newcastle journals has any reference whatever to the occurrence been made I may add here that, as already stated, the Gunnedah, Armidale, Glen Innes, Tenterfield, and other papers published in the north and west, seem to have taken no notice of the phenomenon, so that thus far observation is limited to the districts between Tamworth and the Paterson.

"In answer to your question, "Did it leave any dust, if so, was any collected"? I may repeat that no dust was observed to fall from the dark mist, but the occurrence of high winds raising the usual clouds of dust from the roads would hinder the attempt to distinguish between the dust deposited from either source unless the difference were very clearly marked. I am alluding now of course to observations made at positions within the reach of dust driven from the roads by high winds. In remoter places, I am informed, the only peculiarity remarked in the fog was its singular dryness, together with its discolouration, as compared with usual mists.

"From the best enquiries I have been able to make, such a fog has never been witnessed before by residents in the districts visited, and the subject has been very generally canvassed in the circles of the "oldest inhabitants." A general impression that it was the precursor of blight or an insect visitation existed, probably owing to the fact that some persons of years and education adopted this view of the occurrence and injudiciously (I think) gave their ideas to the less informed and more impressible of the residents. All were agreed, however, that the phenomenon had never been witnessed here before, whatever might be the opinions entertained respecting its origin or consequences

"The time at which the fog first made its appearance in the different districts mentioned seems to involve the subject in more difficulty than it presented at first to myself, but by correspondence

I shall endeavour to obtain further and more precise information upon this point. After perusing your interesting paper and Humboldt's remarks upon dry fogs, with the more remote phenomena recorded by the Roman poet, I can find no parallel to this occurrence excepting in the appearance of cosmical meteoric dust, hypothetically alluded to in your concluding remarks."—H. JONES.

"Times Office, Murrurundi, Nov. 7, 1876.

"From enquiries made since my last, I have gleaned a few particulars, which though imperfect, may be worth communicating. The most important of these have been supplied by Mr. George Armstrong, a gentleman of very extensive colonial experience, at present residing at Walcha. He informs me that the dry fog of the 12th ultimo, was noticed near Bendemeer on the morning of that day, about six o'clock. He was out with some assistants looking after stock in the vicinity of Bendemeer, between that town and Surveyor's Creek, when his attention was attracted by an apparently heavy, widespreading cloud of smoke rolling over the distant mountains. He directed the notice of those who accompanied him to the strange appearance, and the impression left upon their minds was that an immense bush fire had occurred on the hills causing the smoke they imagined to be covering the mountains. They rode in the direction of the mist, and soon discovered that its origin and nature were widely different from those already mentioned. In short they found it to be a dry fog, of such an extent and density however, as to render it quite singular. Mr. Armstrong is a native of South Australia, of which colony his father and uncle were amongst the earliest pioneers, and he has therefore the benefit of at least forty years' clear knowledge of the seasons and phenomena witnessed in these colonies. According to his account, these dry fogs, though not common, have occurred several times within his recollection, but have never had nearly so wide a range as that of last month. Many years ago he encountered one of these fogs at the head of the Wilson River, in the meridian of Capricorn, he was then engaged in driving stock, I think, and when approaching the Valley of Lagoons, witnessed

a phenomenon similar to those under notice, but of a comparatively local character. More recently, while travelling with a large flock of sheep, he noticed a dry fog at Goonoo Goonoo, a station of the Peel River Company, near Tamworth, but this also was of limited extent. The most notable of these occurrences, he says, occurred in South Australia in 1836 in the month of April. That colony had only just been formed at that time, and the phenomenon excited a good deal of apprehension in the minds of the settlers. There can scarcely be any evidence I imagine, of the extent over which the fog of 1836 was observed, as the colony had not then been opened up. The aboriginals associated the occurrence with some mischievous event, the nature for which they could not define. I omitted to mention that at Bendemeer there was no wind perceptible immediately before the fog appeared, but shortly afterwards a slight westerly wind sprang up. The direction in which the fog appeared to the view from Bendemeer, was about south-west by west. The fog appeared to annoy the horses the party were riding. The fog covered the Swamp Oak Creek, Surveyor's Creek and intermediate country.

"This is the extent of my information respecting the fog as it appeared at Bendemeer, but Mr. Armstrong has promised to furnish me with memoranda of this and other dry fogs which he has preserved. If I should receive them I need not add that they will be speedily forwarded to you.

"A friend who visited Clarence Town a day or two after the 12th ultimo, tells me that the fog was the topic of general remark during his stay. In that locality it is said to have presented a dull grey leaden hue, but otherwise preserved the peculiarities noticed elsewhere.

"At Bellevue, near Scone, a number of aboriginals are located, and the fog has not passed them without observation. They take it to be a sign of approaching drought, and they tell of similar appearances having been noticed in past years. This at present is all the additional information I have to offer. I am expecting

more in answer to letters sent to different persons likely to have observed the phenomenon.—H. JONES."

"P.S.—I have not been able to secure any dust, or learn of any having been deposited by the fog or whatever the phenomenon should be termed."

"Yabtree, Gundagai, Dec. 23rd, 1880.

"Having seen your paragraph in *Herald re* dust storm that occurred on Wednesday 15th instant, will state herein the storm as observed here. Yabtree is on the Murrumbidgee about equal distance from Gundagai and Wagga. About 1 p.m. on the 15th the sky became overcast, sun obscured and some hills about two miles away partially so, they had the appearance of heavy rain falling; wind strong from about W.N.W., in a few minutes the dust made its appearance, it was very fine. At first I thought it was smoke coming from bush fires, and although the house was closed, in a few minutes everything inside was covered with fine dust, the storm lasted until about 6 p.m., the sun having been invisible the whole time and wind in nearly same direction, then a few drops of rain fell, the wind fell away to almost a calm, and sky partially cleared, only few rain clouds passing slowly to east, a few more drops of rain fell about 8 p.m. after which the night was a clear one. There are no roads near Yabtree from which the dust could come, so I came to the conclusion that it was due to a storm, and felt disappointed by not seeing any remarks thereon in telegrams in Thursday's *Herald*, except from one station, Euabalong on the Lachlan River, about 200 miles W.N.W. from here, the direction from here to where the *Potosi* passed the mud shower, is about E.S.E., so the Euabalong, Yabtree, and *Potosi* storms were most likely one."—R. F. HORSLEY.

"Tumut, N.S.W., Dec. 23rd, 1880.

I see by your letter in the *Sydney Herald*, dated Dec. 20, that you are anxious to collect all the information you can get as to the showers of mud that fell on board the S.S. *Potosi*, and also at Moruya on Wednesday the 15th December. At Tumut the morning opened calm and hot, about 10 a.m. the wind began to

rise and whirled the dust along in thick choking clouds, which gradually mounted higher and higher into mid air until all the surrounding hills were blotted out, or only seen occasionally, as though a heavy thunderstorm was raging in their vicinity. Thermometer standing, 12·30 p.m. at 94° in the shade, in about the coolest spot to be found in Tumut, viz., large open shed at the Brewery with a thick bark roof, where the beer is cooled before going into the casks, on this occasion the cooling table was covered with cold water to keep the seams tight while no brewing was going on.

"As Wynyard Street was the main channel of this terrific storm of dust, at times one side of the street was quite invisible to the other, shops had to close all doors, and even then a very fine deposit of dust remained on everything after the storm was over, which eased itself down as the sun declined, and was entirely over at sunset. The fine dust seemed to have attained an altitude of from one mile to a mile and a half, and was travelling from about W.N.W. to E.S.E. (no compass here). When over, the roads were swept clean of fine dust, and the coarse sand lay in regular ridges the same as waves leave it on the sea beach. Perhaps Adelong could give further information as the storm came from their direction. No doubt the fine dust travelled out to sea until beat down by the rain, for I see by the public prints that you had this storm at Sydney the same night. I enclose some of the fine dust obtained from nooks and corners of elevated places, so that you may compare it with that your Moruya correspondent sent you."—EDWARD ALLEYNE.

" Moruya Heads, Meteorological Station, 22nd Dec., 1880.

"I have forwarded three samples of the mud or dust shower of the 15th instant, the samples have been carefully collected with a very fine brush, and I think contain very little of any other matter than that which fell during the shower, a great deal has been blown away since the 15th, though now all the bushes, leaves, small trees, etc., show it very plainly. On the morning after the shower a few pounds weight could have been collected from tubs, buckets, rain gauge, etc., but it was all thrown away.

"Concerning the shower, no particular notice was taken of it, the drops were large. It had been gloomy all day and threatening and a low barometer; we had a southerly squall about 6 a.m., which cleared off about 8 o'clock, mizzling rain at 9 and cloudy, wind light southerly, with a smart shower at 10, then light showers until 2 or 3 o'clock the following morning. At 5 a.m. 16th, the weather was fine and clear. We had a quantity of clothes on the grass all night, which were all covered with mud, yet only thought it strange how it came there, until reading about the *Potosi* steamer having been in such a shower. She must have been about 40 miles south of the Moruya heads at the time. I have not heard of it being at any other place than Moruya, and a few miles along the south coast, it looks very much like the rust on wheat."—R. M. Tranent.

"Yass, 23rd December, 1880.

"I noticed by Tuesday's *Herald* that you wish to get information about the late dust storm. I am informed by several parties that the storm rose a long way back, most of the dust rising off the stations between the Lachlan and Darling, crossing over Condobolin, Euabalong and Forbes, about 12 o'clock on Wednesday morning the 15th. I have been living in the Cobar district many years, and always found the dust very bad in summer, especially in very dry times. A flock of sheep going in to get water at a tank will rise the dust so that it can be seen plainly at a distance of 30 and 40 miles, travelling in the air the same as smoke from a bush fire, (and it takes an experienced hand to tell the difference). I may mention the dust passed over Gunning between 5 and 6 o'clock on Wednesday evening 15th, the wind being from south-west."—C. E. Armitage.

"Wingen, Jan. 23rd, 1884.

"We have had here a rather remarkable appearance in the air. On Sunday morning January the 20th, the thermometer record for the previous 24 hours was 88 max. 53 min. with wind blowing from the west, and that night we had a light thunderstorm with 41 points of rain. On Monday the 21st the thermometer

record for previous 24 hours was 98 max. 60 min., and the wind blowing strong from the north-west, and the country was covered all day with a light haze which did not appear at all like smoke nor like ordinary dust. This continued all day, and on Tuesday morning the thermometer record for the previous 24 hours being 84 max. 55 min., the wind blowing strong all day from the same point, the country was still covered with haze. To-day Wednesday the 23rd, the thermometer record for previous 24 hours was 81 max. 57 min., wind blowing from the same point, the haze has quite disappeared. The wind during the whole time seemed cool and moist, which seemed the more remarkable, as we have for weeks past been having hot dry winds from the same point. The idea which suggested itself to me was that there had been heavy rain in the north-west, as the feeling in the air and the appearance was much like what sometimes occurs in Sydney when a southerly buster comes up after a very hot day."—W. E. ABBOTT.

"Dust Storm of August 14th, 1885, as seen at Hay.—The night of the 13th August, during the ride in the coach from Gunbar to Hay was most beautifully clear. At the commencement of the last stage, 20 miles from Hay at 5 o'clock a.m., August 14th, the wind was blowing pretty freshly from the North. Later on there was a magnificent sunrise, the air being as clear as could be. On reaching Hay about 7·30 a.m., the wind was blowing strongly and increased up to 10 a.m., when it was blowing in heavy gusts from the north. It continued in this way till about 2·30 p.m., when it gradually grew calmer and veered to the south-west. At 7·30 a.m. the barometer stood at 29·396. It fell steadily until 2 p.m. when it commenced to rise. About 10 a.m. the whole place was enveloped in a light reddish-brown fog, which continued all day. The particles of dust composing this fog, if it may be so called, being too fine to be seen, no motion was observed although the wind was blowing in strong gusts. The day was warm and rather close, the temperature being 70°. A light reddish-brown dust was deposited on everything. The wind got much calmer towards evening, and after sunset a slight shower of rain fell.

The morning of the 15th was fine and rather cold. There were a few cirrus clouds, the white back-ground of which showed a slight reddish tinge in the air which could not be seen against the blue sky. The rain gauge showed about ·003, rain with a deposit of mud about ·001."—J. ARTHUR POLLOCK.

"Buckingbong, Narandera, 13th Feb., 1885.

"Narandera and the neighbourhood seem to be about the worst places visited, as far as I can learn the storm travelled from Hay to Narandera in 1½ hours, and from Narandera to Wagga 1 hour, but the wind on the surface did not I think exceed 20 to 30 miles an hour, nor was there much dust near the ground, the wind in the clouds seemed of a whirlwind nature, the appearance before darkness came on being very wonderful, the clouds were rolling and rolling over and under one another. You will probably know that the storm struck Narandera about 2·15 p.m. and total darkness lasted for 15 minutes, succeeded a like time by a sky of red so brilliant you could scarce look at it. I may mention the darkness was blacker or more intense by far than the darkest night. I have interviewed many people since, men who have been in the colonies 50 years or more, but they aver they never saw anything like the storm of Friday, February 6th."—B. BLAIR.

"Kymba, August 15th, 1885.

"At 9 a.m the wind was N.E. moderate, with the sky slightly hazy, and a mild feeling in the air, similar to what would be experienced on a mild summer morning, although the minimum temperature during the night had been 30°. The barometer (an aneroid) registered 28·50, being ·10 lower than at 9 p.m. the previous night. By noon the haze had gradually thickened, and the wind had veered to N.W., but came in variable gusts, and the barometer had fallen to 28·35. Shortly after noon, the clouds which came in the wake of the wind which had increased to a gale, assumed a peculiar aspect—a dun or salmon colour, and the surrounding hills became enveloped in a light yellow, foggy haze which was thought to be rain. At 3 p.m. the barometer registered 28·33 and remained steady till 6 p.m. The gale blew with con-

siderable violence during this time. After sunset rain commenced to fall in showers with strong gusts of wind, and with the rain a quantity of mud fell which bespattered everything. As an instance, iron tubs placed under spouts had one eighth of an inch of a red deposit at the bottom this morning, and roofs and outbuildings bore traces of the discolouration. Twenty seven points fell up to 9 o'clock this morning, and the barometer has been gradually rising since, although light showers have fallen at intervals through the day. As a mud or dust storm seems so unseasonable at this time of the year, I have dried a small quantity of it, and enclose in this letter, as it may be useful in your observations on the subject. The country in this immediate neighbourhood is too damp from the effect of the recent showers to furnish any dust. I may state that the altitude of this place above sea level is 1,036 feet according to Mr. Railway Surveyor Jamieson, who kindly informed me some time ago. The highest reading of the aneroid has been 29·36 since I have had it."—R. J. Barr.

"Narandera "*Argus*" Office, August 24th, 1885.

"Some time since Mr. Bryce Blair of Buckinbong Station near Narandera, requested me to forward to you details of the very severe dust storm which passed over this district on Friday the 6th of February last. I enclose herewith extracts from the *Argus* of the 7th of February, which of course can only be accepted from a paragraph point of view. My personal experience I give you briefly in narrative form—" I returned to my office shortly after two o'clock, there was at that time every indication of a heavy dust storm coming from the west, in the course of half an hour the town was enveloped in dense clouds of red sand, that was no more than the usual experience at intervals during the summer, but suddenly, there came a black column (like the densest smoke in appearance) which made the place darker than the darkest night I ever experienced, it was in fact the first occasion upon which I realized absolute darkness. Many people in speaking of it afterwards assured me that they had, from very fear, to remain where they were when overtaken by this cloud, for myself I may say

that, in my office, just before the storm, I had moved from the window, and suddenly I was so confused by the intense blackness that I could not possibly tell where the window was placed, and though knowing perfectly well in what part of the room lucifers etc. were usually kept, I had to grope about for some time before I could secure the means of kindling a light. As a matter of fact I can say nothing stronger than that, it was darkness that could be felt."—GEO. ELDRIDGE.

"Gundaroo, 30th December, 1885

"Such an unusual and strange occurrence took place here this morning, that I thought I would communicate it to you. About half-past six a.m. on looking out the whole of the hills in the distance, west and south, seemed enveloped in a cloud of dust or fog which gradually rose and worked round south to east. About seven, the hills west were cleared, but the dust hung in mid air like a cloud, excepting at two or three places, where it hung as if the dust was falling like a shower of rain; at about a quarter past seven it had all blown in a body to the south, which was so dense that the hills only a short distance away could not be seen, and then it came blowing down direct north, it then took a north-west direction and died away. Now at a quarter to eight a.m. there is hardly a breath of air, with the sun shining out hot; during my thirty-one years residence in this part I never saw the like before, and thought such a strange occurrence deserved notice being taken of, and this is my reason for troubling you with the details."—WILLIAM AFFLECK.

The following articles and letters upon atmospheric dust and dust storms from other parts of the world are not only interesting, but they throw a great deal of light upon the subject of meteoric or atmospheric dust and dust phenomena generally as experienced in Australia, many more examples could have been given, especially if the meteorological publications had been laid under contribution; those given are some of those noted down in the ordinary course of reading.

Dust Atmosphere of China.—J. P. O'Reilly, Dublin, in a letter to "*Nature*," January 17th, 1884, quotes from von Richtofen's work upon China, in reference to the dust atmosphere so characteristic of Central Asia and more particularly of the *loess* district:—"Even during complete calms the atmosphere is often for many days yellow and opaque. The view is completely hemmed in and the sun appears merely as a dull bluish disk."

More markedly is this character presented by these peculiar dust storms so well known to travellers visiting Tien-tsin and Pekin, and even more so to those who travel in the interior of the N.W. provinces of China. The wind then blows from Central Asia and everything becomes covered with a fine yellowish dust.

"In Shensi where the air is rarely clear and transparent, the whole landscape has a yellow tint, streets, houses, trees, crops, and even the traveller one meets on the road, and the air itself, one and all are yellow coloured."[1]

A writer in "*Nature*," Aug. 12th, 1886, p. 348, quoting from an article in the American Meteorological Journal, upon the dust storms of Pekin, says:—"These occur in the dry season, especially in the winter and early spring; they come on at irregular intervals, perhaps six or eight times in the season, and last about three days. The wind is W. or more often N.W. and blows fresh or high. The dust extends eastward from Pekin to the sea and south eastwards it regularly descends as far south as the Yellow River, and sometimes to Shanghai 10° of latitude away."

The writer of the paper says this vast quantity of dust must come from the great deserts of Mongolia. He also refers to the variations in the barometer and thermometer accompanying the storms, and to the obscuration of the sun, which was set in a ring.

[1] See also Johnson's "Journey to Ilchi the capital of Kotau."—(Royal Geogr. Soc., 1867, p. 5.)

Dr. H. B. Guppy, in "*Nature*," June 9th 1881, says that in the spring of 1878 his attention was directed to the dust-winds which are of frequent occurrence in the valley of the Yang-tse in the warm and dry season of the year. According to his observations at Hankow, they sometimes had the appearance of a dense mist, and at other times the air seemed to be penetrated by a fine haze, and in all cases a fine and impalpable dust was deposited, which was with difficulty excluded from the interior of the houses. Their duration lasted from a few hours to two days. He concluded that they are not local phenomenon from the fact that one was experienced simultaneously from Hankow to Chinkiang a distance of nearly 450 miles. The dust resembles the loess of the alluvial plains of the Yang-tse, and is generally made up of siliceous or calcareous particles from $\frac{1}{1000}$ to $\frac{1}{300}$ inch in size, and vegetable débris. From a study of the meteorological and electrical conditions of the atmosphere, he does not think they are due to sudden breezes.

Prof. S. P. Langley, of the Allegheny Observatory, Penn., in speaking of the red sunsets seen all over the world, says ("*Nature*," 31/1/84) "we know of but two likely causes: one is the advent of an unusual amount of meteoric dust. While something over ten millions of meteorites are known to enter our atmosphere daily, which are dissipated in dust and vapour in the upper atmosphere, the total mass is small, compared with the bulk of the atmosphere itself, although absolutely large. It is difficult to state precisely what this amount is . . . approximately not greatly more than 100 tons nor greatly less than 1,000 tons a day.

"Taking the largest estimate as still below the truth, we must suppose an enormously greater accession than this to supply a quantity sufficient to produce the phenomenon in question; and it is hardly possible to imagine such a

meteoric inflow unaccompanied by visual phenomena in the form of "shooting stars," which would make its advent visible to all. Admitting then the possibility of meteoric influence we must consider it to be nevertheless extremely improbable. There is another cause, which I understand has been suggested by Mr. Norman Lockyer—though I have not seen his article—that of volcanic dust."

Prof. Langley then speaks of the dust present in the apparently clear air of the upper parts of Mt. Etna, surrounded by snow fields and deserts of black lava, yet the telescope showed that the air was filled with minute dust particles, which evidently had no relation to the local surroundings, but apparently formed a portion of an envelope common to the whole earth.

In 1881 Prof. Langley was on Mt. Whitney, Southern California, with an expedition from the Allegheny Observatory, where from a height of 15,000 feet they looked down upon a kind of level dust ocean, invisible from below, but whose depth was six to seven thousand feet. The colour of the light reflected from this dust was clearly red and it stretched in every direction as far as the eye could reach, although there was no special wind or local cause for it. It was evidently like the dust seen in mid ocean from the Peak of Teneriffe; something present all the time and a permanent ingredient of the earth's atmosphere."

Mr. Clarence King, Director of the U. S. Geological Survey, thought that this upper dust was probably due to the "loess" of China having been borne across the Pacific and quarter of the way round the world. We were at the top of the continent and the air which swept by us was unmingled with that of the lower regions of the earth's surface. Even at that great elevation the dust was perpetually present in the air, and I became confirmed in the opinion that there is a permanent dust shell enclosing the

whole planet to a height certainly of about three miles, and probably to a height even greater. The meteorites which are consumed at an average height of 20 to 40 miles must add something to this."

E. Metzger, in a letter to "*Nature*," 17/1/1884, p. 261, draws attention to the presence of particles attracted by the magnet in the sand dunes near Scheveningen.

Some atmospheric dust collected at Klagenfurt, Carinthia, after a rain of mud, which had taken place on Oct. 14th, 1885, was found to consist of minute crystalline granules and flakes of quartz, opal, orthoclase, biotite, phlogopite, pyroxene, amphibole, mica, talc, kaolin, chlorite, rutile, anatase, zircon, tourmaline, ferruginous clay, spinel, magnetite, pyrites, magnetic pyrites, calcite, magnesite, dolomite, and apatite; metallic iron could not be found. Diatoms etc., were present, together with a few carbonaceous or carbonized substances, such as the spores of fungi, filaments of algæ etc., silicified membranes of parenchymal cellules, and pyritised and silicified spherules resembling pollen. Its reddish yellow colour, resembling the "Passat" dust, may be against its having come direct from the Sahara.[1]

In an address delivered to the Royal Meteorological Society, Jan. 15th, 1890, Dr. William Marcet, F.R.S., President, quotes from a paper by Dr. Cook in the Journ. Roy. Meteorological Society, who says that in India there are some days on which however hard and violently the wind may blow, little or no dust accompanies it, while on others every little puff of air or current of wind forms or carries off with it clouds of dust. If the wind which raises the dust is strong, nothing will be visible at the distance of a few yards, the sun at noon being obscured. The dust

[1] Dr. M. Schuster, Imp. Acad. Vienna, Jan. 14, 1886; and Geol. Mag. 1886, p. 122.

penetrates everywhere, and cannot be excluded from houses boxes, and even watches, however carefully guarded. The individual particles of dust appear to be in such an electrical condition that they are ever ready to repel each other and are consequently disturbed from their position and carried up into the air. Dr. Cook also describes dust columns and dust storms, and the electrical origin of both.

In a letter dated Tokio, April 23rd, Prof. J. Milne, F.R.S., states, ("*Nature*," June 29, 1892) that the commander, Capt. R. Swain of the S.S. *Yokohama Maru*, gave him a specimen of some dust which fell on the vessel on April 2, when about 95 miles west by south of Nagasaki, at about 6 p.m. The sun appeared quite yellow. The atmosphere was moist and rendered everything upon the deck of the ship quite damp; the precipitated moisture was yellowish, and as it dried it left an extremely fine powder. For two days previously the wind had been blowing W.S.W. or from China. Nothing was felt in the eyes, and if the ship had not been covered with a yellow powder, the phenomenon would have been regarded as an ordinary but peculiarly coloured fog. . . . The probability is that the material came from the loess plains of China. At Nagasaki which is 300 miles from the coast of China, a yellow sun was noticed on the morning of the 2nd and during the day while the dust was being precipitated, the appearance of the atmosphere was compared to a London fog.

On April 1st there was a fall of dust at Nawa in Okinawa-ken, and on the 2nd dust fell at Gifu. The P. and O. steamer *Verona*, which left Hongkong on April 1st experienced the same phenomenon as the *Yokohama Maru*, the vessel being covered with a fine dust, and there was so much haze that land was not seen until reaching Nagasaki. On April 3rd, a yellow sun was seen at Yokohama, but I am not aware that any dust was observed. Roughly speak-

ing, it therefore seems that on April 2nd, at a distance of from 200 to 400 miles from the coast of China, there was a cloud of dust which may have been over 1,000 miles and possibly 2,000 miles in length. Dr. B. Koto, who examined the dust tells me that the particles are chiefly felspar, but there is a little quartz and shreds of plants.

An article referring to a shower of dust in connection with snow in Indiana and Kentucky, appeared in the *Monthly Weather Review* in 1895.[1] The dust does not appear to have been the nuclei of the snowflakes, but was intermingled in the air with the snow and fell during an interval between two snow storms. The examination of a large number of specimens showed that the dust was made up largely of silt, mixed with organic matter. A number of fresh water algæ were present, though they appear to have been dead and dried for some time. . . . Everything indicated that the material had come from the bottom of some dried up lake, pond, marsh or river bed. The dust was almost identical with the so-called "loess" formation, which covers very extensive areas in Illinois, Indiana, Nebraska and adjoining States, its depth in some places amounting to 100 feet or more. This is interesting, because there is a long standing controversy as to the origin of the "loess" of the north-west. Certain portions of the "loess" formation of Asia are known to be wind deposits, and there is very strong presumptive evidence, now borne out by the examination of the samples of dust, that much of the "loess" of the Western States is also a wind deposit. . . . . This light soil is easily raised and carried off by strong winds of the western plains of America; instances have occurred in which six inches of surface soil have been blown away from freshly cultivated fields in the course of a single wind-storm.

[1] "*Nature*," August 29, 1895, p. 419.

J. M. Yates, writing from Davenham, Cheshire, "*Nature*" 1/4/97, says:—"On Tuesday morning, March 22nd I noticed on the glass of our greenhouse and on many of the shrubs, a sort of red dust. On making inquiries I found the same thing existed about two miles due west, I collected some, and by the kindness of Messrs. Brunner, Mond & Co., it was examined in their laboratory. The report says:—The dust showed minute fragments of clayey matter mixed with quartz; organic matter, such as pollen grains, was absent. The particles are about ·0001 millimetre in diameter, many of them less. We are surrounded by grass; the soil is clayey loam, without oxide of iron or quartz."

A letter from Augusto Arcimis, "*Nature*," 21/4/98, in reference to the dust shower met with by the *Roslyn Castle* off the west coast of Africa, describes the phenomenon as experienced at the City of Laguna, Teneriffe. "A light fog was observed from the early hours of the evening of Feb. 15th, with a light breeze from the east. During the night it rose to a moderate gale. At about 5 a.m. on the 16th a few drops of rain fell. The wind dropped to a gentle breeze again during the day, from the east. The fog became denser and the sun pale and feeble like the moon. The drinking water became salty and coloured as by oxide of iron. The dust was grey and extremely fine, and was deposited on every object."

Some brown dust was collected on board the P. and O. S. S. "*Sumatra*," during a thunderstorm in the Galita Channel, Mediterranean. Mr. G. T. Pryor, ("*Nature*," 29/6/99) found the dust to be an argillaceous and calcareous sand, containing a little organic matter, and a few angular grains of quartz.

Prof. Rücker, F.R.S., (now Sir Arthur Rücker) writing from Taormina, in Sicily ("*Nature*," 28th March, 1901) on March 12th to Prof. Judd, says:—"We have had a rather

curious phenomenon here. The sirocco was blowing and the hills were wrapt in mist, but the fog assumed a yellow hue, and the sun which at times could not be seen through it, was a bright blue. This was caused and accompanied by a copious fall of red dust. Some which I shook off my hat was quite dry, and on looking at it through a low power lens, all the granules appeared to be spherical, except a very few grains of what looked like quartz. . . . This dust also fell at Naples and Palermo in such quantity that the streets looked red and the people were frightened." Prof. Judd states that under the microscope the dust is seen to be made up of particles of quartz, mica etc., also frustules of freshwater diatoms. Prof. Rücker, "*Nature*" May 9, estimates the amount from his observation as about 7 tons per acre.

Sir Ed. Fry, F.R.S., wrote to "*Nature*" from Failand, January 28th 1902, describing a fall of reddish or rust coloured mud or dust, which covered greenhouses, plants, and clothing out to dry; it also fell at Lawrence Weston, about five miles to the N.E., Chewton Priory some fifteen miles S.E., and Barry Island some twenty miles W. by S. and on the other side of the Bristol Channel. The above fall was afterwards found to have spread over a large area, since it occurred in Cornwall.

On March 6th there appeared a letter in "*Nature*" from Mr. Clement Reid, stating that the above fall of red dust in South Wales may have been derived from the Red River dust flats, as he had noticed red dust clouds blown from the flats and spreading across St. Ives Bay to St. Ives Head, a distance of over three miles. The wind was not a gale, but merely a strong dry east wind.

Gold and platinum? in meteoric dusts.—For convenience the results of the search for these metals are summarised here instead of being given under the headings of the

various specimens examined. Minute quantities of gold were met with in two of the dusts examined, viz., from Gundagai and the University tank, that from the University beams also yielded a metal resembling platinum, some of the other dusts have yet to be tested. These metals were especially sought for when grinding and washing the dusts in an agate mortar to separate out the particles of metallic iron, as this is a much more delicate test for minute quantities of gold and platinum in such materials than any chemical test; they were obtained in the form of minute spangles.

The dust from the University beams, collected in 1882 from a portion of the roof some distance from the Chemical Laboratory and completely cut off from it by several dividing walls and the ceilings, yielded a minute spangle of a white malleable metal insoluble in nitric acid even after evaporating the acid down to dryness, hence it appears to be one of the platinum metals. The particle was too minute to admit of applying other wet tests, hence it was not treated with aqua regia.

A dust from Muswellbrook (N.S.W.) yielded particles of a non-magnetic grey metal readily soluble in acid, this was probably zinc or zinc and lead from a galvanized iron roof. Hartley and Ramage found lead in several meteorites, in volcanic and other dusts, as well as in chimney soots (Proc. Roy. Soc. 1901).

The mud from the University tank, which may have been collecting for 30 years, as the tank had probably never been cleaned out since it was put up, yielded spangles of a yellow malleable metal, insoluble in nitric acid even on evaporation, and therefore presumably gold, the metallic particles although visible without a microscope were very small and insufficient for the application of other tests; there were also present particles of a yellow metal resem-

bling gold but soluble in nitric acid, these may have been copper or brass, (as copper is almost invariably present in meteorites it may have had a meteoric origin); the Menindie dust also contained a yellow metal soluble in nitric acid. The dust from Gundagai yielded a yellow malleable metallic spangles insoluble in nitric acid, and therefore presumably gold.

In most cases some of the metallic spangles were visible without a lens, these were separated from the rest of the material left in the mortar by picking them up on the point of a needle and transferring them to a slide for examination under the microscope; under a one inch objective, they still looked like gold, the action of the nitric acid was also watched in the same way; some of the soluble ones were seen to dissolve slowly, others quickly with many minute gas bubbles.

The gold and platinum may or may not be of meteoric origin, but as both metals have been met with in meteorites, (an account of the occurrence of gold in meteorites will be given in a subsequent paper) and platinum has apparently been previously found in meteorites,[1] it is not impossible that both the gold and the platinum metal may have had a cosmic source, although it is much more probable that the gold has been windborne from some auriferous area, for even the sandstone and shales about Sydney contain traces of gold.[2]

Conclusion.

I have quoted what may be considered by some as an unnecessarily large number of accounts of meteoric dusts, dust storms, rains of mud, dry fogs, etc., but I do so because some of the explanations given by different observers do

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[1] Davidson, Am. Journ. Sci., 1898. Mingaye, Report of the Dept. of Mines, Sydney, 1898, p. 21.

[2] A. Liversidge—Journ. Roy. Soc. N.S.W., 1894, pp. 185 - 188.

not appear to quite account for the phenomena, and it appears to be desirable that sufficient evidence is needed for each to judge for himself. My own opinion is that the phenomena of dry fogs or haze, of dust storms and mud rains are not due to extraterrestrial causes; I think that the material or dust is mainly made up of débris, inorganic and organic, from the land and occasionally as everyone is aware of volcanic dust; mingled with this undoubted telluric matter there appears to be nearly always a certain amount of extraterrestrial or cosmic matter, *i.e.*, the dust or débris of meteorites, although in most cases it is very difficult or even impossible to discriminate between the terrestrial and the cosmic dusts.

The presence of cobalt and nickel in the iron of a dust was formerly regarded as a proof of its meteoric origin, but it is now known that both of these metals occur in the metallic iron met with in some rocks, and notably in the telluric irons of Greenland, nickel has also been found in dust from volcanoes, and in the soot from coal smoke by W. Noel Hartley, F.R.S., and Hugh Ramage, (Proc. Roy. Soc., March 1901, p. 97). They also found other metals in soot, *e.g.*, copper, gallium, thallium, silver chromium, lead, etc. Both nickel and cobalt occur in some varieties of commercial iron and steel, cobalt is especially likely to be present in traces in Bessemer or other steel in which spiegeleisen or other manganese alloy is used in the manufacture. A piece of a Sydney tram rail, a horse shoe picked up in the street and nails from the same all yielded traces of cobalt; nickel was not tested for as the presence or absence of cobalt was regarded, for the purposes of this inquiry as of more importance.

In spite of the presence of cobalt and nickel in some telluric irons, dusts and soils, I still think that some, if not most of the metallic iron (containing nickel and

cobalt) found in dusts, such as have been described in this paper, is of meteoric or cosmic origin; the particles resemble those obtained from meteorites and do not look like pieces abraded from manufactured articles, further they are not usually rusted to any great extent, whereas small particles of ordinary iron and steel (even if small amounts of cobalt and nickel are present) usually rust quickly; the difficulty is to prevent them passing wholly into the form of oxide, then too, the minute spheres of iron found in what are regarded as meteoric dusts and deposits are not found in flue dusts nor in volcanic dusts; as already pointed out, they have, however, been formed artificially by Professor Schuster from meteorites.

The following shows however, that a telluric form of spherulitic iron does occur:—In the Trans. of the Royal Society of Canada for 1890, Dr. G. C. Hoffmann describes an occurrence of metallic iron containing nickel and cobalt on St. Joseph Island, Lake Huron, Ontario. The iron occurs as minute spherules in a thin coating of limonite on the fissure faces of surface specimens of quartzite, the spherules amounting to 60% of the coating by weight. The largest spherules are about ·3 mm. in diameter. Sp. gr. 6·86. The part of the spherules soluble in hydrochloric acid contained:—

Iron...	97·79	Sulphur	·13
Magnesia	·57	Phosphorus ...	1·07
Nickel	·11		——
Cobalt	·23		100·00
Copper	·10		——

The portion insoluble in hydrochloric acid (nonmetallic) 9·76% was made up of spherical and ovoid grains and consisted mainly of silica. The spherules were made up of a siliceous nucleus, coated with a humus like substance which in turn was covered with the metallic layer; the author

suggests that this metallic layer was probably due to the reduction of an iron salt by organic matter.

The presence of a nucleus of silica or other non-metallic matter in the spherules regarded as of cosmic origin has not been recorded; further the meteoric spherules show traces of fusion, hence I think the Canadian spherules are quite distinct.

Finally, although there appears to be no doubt, whatever, that there is a constant gentle rain of meteoric dust falling upon the earth's surface, and at times it is probably greater than at others, especially after the periodic meteor displays, the evidence certainly does not show that the dust storms, dust, haze, red rain, mud showers, etc., are due to any unusual descent of meteoric matter, hence it is a misnomer to call the deposits from such "meteoric dust."

NOTE.—Certain minor additions have been made to this paper during its passage through the press.—A.L.

Occurrence of GADOLINITE in WEST AUSTRALIA.

By Bernard F. Davis, B.Sc.,

With notes by W. G. Woolnough, B.Sc., F.G.S., and Prof. T. W. Edgworth David, B.A., F.R.S.

[*Read before the Royal Society of N. S. Wales, October 8, 1902.*]

Introduction.—The mineral described by Mr. Davis in the accompanying paper was obtained by him at Cooglegong, in the Pilbarra District, West Australia. He submitted it in April, 1901, to Mr. W. G. Woolnough, B.Sc., and myself for a preliminary examination. Its general appearance at first suggested that it was allanite, but a blowpipe examination of the mineral by Mr. Woolnough showed that it was either gadolinite or some very closely allied mineral. Mr. Davis took the mineral with him to England, promising to analyse it, and send the analysis for publication in our Proceedings. The analysis reached me at the end of last year, but too late for the 1901 session of our Society.[1]

Mode of occurrence.—"Dr. Bonney very kindly examined the rock specimens which I brought home from the same district in which these minerals occur. They were gneisses and granites of marked archæan type. Field evidence showed that a more acid granitic rock, usually very coarsely crystalline, had intruded the gneiss, sometimes breaking across the planes of foliation without disturbing their direction, and by working along the planes of foliation becoming absorbed into the structure of the gneiss. In fact one had the process of gneiss-making before one.

"Dr. Bonney thought that the granitic intrusion was proably very little later than the original gneiss. The lodes

[1] The portions of this paper in quotation marks are taken from the letter from Mr. Davis.

carrying cassiterite, gadolinite, monazite, etc. occurred in the gneiss."

Physical Characteristics.—Colour black in mass, like coarse bottle glass. In splinters transparent and grass-green. Weakly doubly refracting. Pleochroism distinct but not strong, from grass-green to slightly bronze-green. Streak light greenish grey. Lustre vitreous and somewhat greasy. Fracture conchoidal to subconchoidal. Hardness 7, brittle. Specific gravity, as determined by Mr. B. F. Davis 4·14.

The mineral occurs in large masses as much as 10 cm. in diameter, approximately rhombic in cross section, though not sufficiently definite in shape for crystalline form to be determined. The masses appear to be roughly prismatic and are interrupted by an imperfect transverse parting, the division planes being covered with a film of yellowish-green decomposition products.

The mineral is intergrown with white felspar to a certain extent. The central portions of the gadolinite individuals are free from felspar, which occurs zonally about the periphery roughly defining the crystals of the host. This fact indicates that the crystallisation of the gadolinite on the whole preceded that of the felspar, though the two periods overlapped somewhat. The portions of the gadolinite exposed to the weather have undergone considerable decomposition, the resulting product being reddish earthy limonite with a concentric structure and a thickness up to 3 or 4 millimeters.

The following is the analysis by Mr. Davis :—

Silica	23·33	
Ferrous Oxide (FeO)	10·38	
Glucina (BeO)	12·28	
Cerium Oxide (Ce_2O_3)	2·50	
Lanthanum and Didymium (La_2O_3 and Di_2O_3)	18·30	54·16
Yttrium group calculated as (Y_2O_3)... ...	33·40	
Magnesium Oxide (MgO)	·69	
Loss on ignition	·32	
	101·20	

"A small percentage of iron is present as ferric oxide. The BeO includes any alumina which may be present, although I found none in the qualitative analysis. This result seems very high, and I think the high total is probably due to this. 54·16 represents the percentage of the oxides together, obtained by igniting the oxalates with addition of a drop of nitric acid at the end. The percentage of yttrium is probably slightly lower and the lanthanum and didymium correspondingly higher.

"Dr. Norman Collie very kindly examined the mineral for helium and other gases. He says that 10 grams on heating gave about 10 cc. of CO_2 and 10 cc. of hydrogen, a little nitrogen and about one bubble of helium. No argon. In his first experiments he thought he detected argon, but it must have been an impurity from the air.

"The method of analysis was as follows:—Decomposition of the mineral with hydrochloric acid and estimation of the silica in the usual way. Filtrate made up to known volume and measured quantities taken for different estimations. In the slightly acid solution the cerium and yttrium earths were precipitated with excess of oxalic acid while boiling and allowed to stand usually for twelve hours, sometimes two or three days. The filtrate containing iron and glucinum was evaporated with sulphuric acid and after taking up with hydrochloric acid, ammonia added and the iron and glucinum oxides weighed together. The iron was estimated volumetrically. The oxalates of the cerium and yttrium elements were converted into sulphates and separated by standing two or three days with saturated solution of pot. sulphate. The cerium was estimated both by fusion of the nitrates with nitre and also by Mosander's method. I did not think it necessary to go over the analysis again to correct these errors or verify the result as given. For our present purposes it is sufficient, and

shows the mineral is "gadolinite" with a rather low percentage of yttrium earth, but otherwise of normal composition.

Amongst the minerals I brought from the north-west, I have two varieties of a mineral allied to "euxenite" in physical characteristics, as described by Dana. One differs from the other in having more manganese in the place of uranium. They are essentially *niobates* and titanates, (with tantalum) of *uranium*, iron and *yttrium earths*, with the cerium earths and thorium. They occur with cassiterite and monazite in the wash dirt. I have only a few small pieces, but one mineral at least was not uncommon. I saw it in all the tin we bagged from different parts of the country. I hope to start an analysis of one of these if time permits."

INVESTIGATION IN REGARD TO THE COMPARATIVE STRENGTH AND ELASTICITY OF PORTLAND CEMENT MORTAR AND CONCRETE WHEN REINFORCED WITH STEEL RODS AND WHEN NOT REINFORCED.

By W. H. WARREN, M. Inst. C.E., Wh. Sc., Challis Professor of Engineering.

[*Read before the Royal Society of N. S. Wales, December 3, 1902.*]

THE following investigation has been undertaken in order to supply data for use in the design of armoured mortar and concrete constructions, such as the Monier system, and consists of tension, compression, and transverse tests of mortar and concrete when reinforced with steel rods, also of tests under similar conditions when not reinforced. The mortar consisted of one part of Portland cement to two, three and four parts of washed river sand, which had been passed through a sieve of 400 and caught on a sieve of 900 meshes per square inch.

Tension Tests.—The size and shape of the test pieces used for tensile tests is shown in Fig. 1, and the arrangements for holding it in the testing machine in Fig. 2. Fig. 3 shows the test piece fixed in a horizontal testing machine. It will be observed that the shackles are so designed that the tensile stress applied is equally distributed over the area of the cross section under test, which is 100 × 100 mm., or 4 inch × 4 inch; the length over which the elongations were measured is also 100 mm., or 4 inches.

The shackles are held in a horizontal plane by means of four springs which allow them to be adjusted by means of

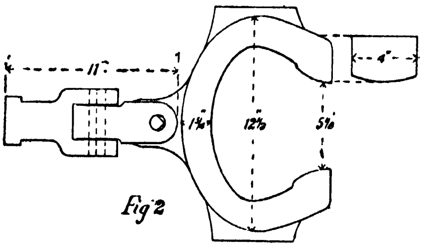


Fig 2

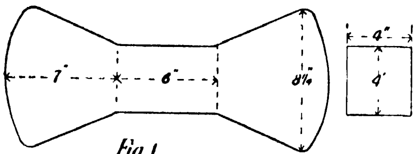


Fig 1

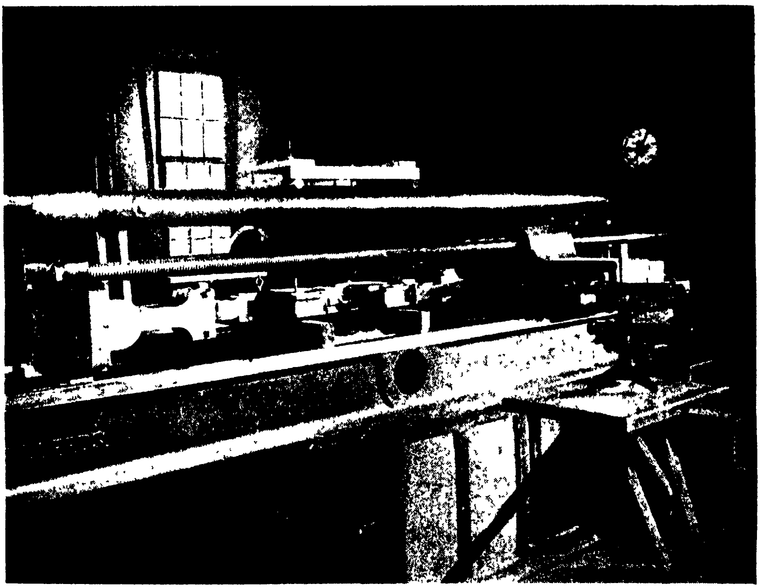


Fig. 3—Shewing tensile test-piece in small Testing Machine, with Martens' Mirrors attached.

four screws; a spirit level is laid on the test piece while it is being fixed in the machine, and set accurately in a horizontal plane. A double set of Martens' mirror apparatus is then attached, by means of which the elongations are observed, using two reading telescopes and scales on each side of the test piece. The elongations can thus be measured to $\frac{1}{1000}$ mm., or $\frac{1}{25000}$ of an inch. In these tests the elongations have been recorded for multiple of ·00004 of an inch.

Tables I. and figs. 4, 5 and 6 give the results of testing the mortars at ages varying from two to twelve months, in which the coefficient, or modulus of elasticity, has been calculated at stresses varying from about 50 lb. per square inch to as nearly as possible the breaking stress. Table II. and figs. 7 and 8 give the results of testing similar pieces

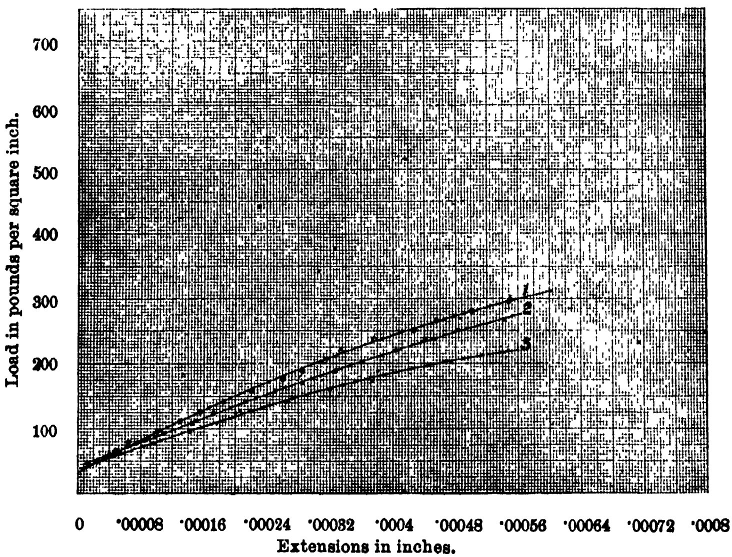


Fig. 4—Tensile Tests of Mortar Briquettes. Age 12 months.
No. 1—One Hemmoor Cement to two Emu Plains sand.
No. 2— „ „ three „ „
No. 3— „ „ four „ „

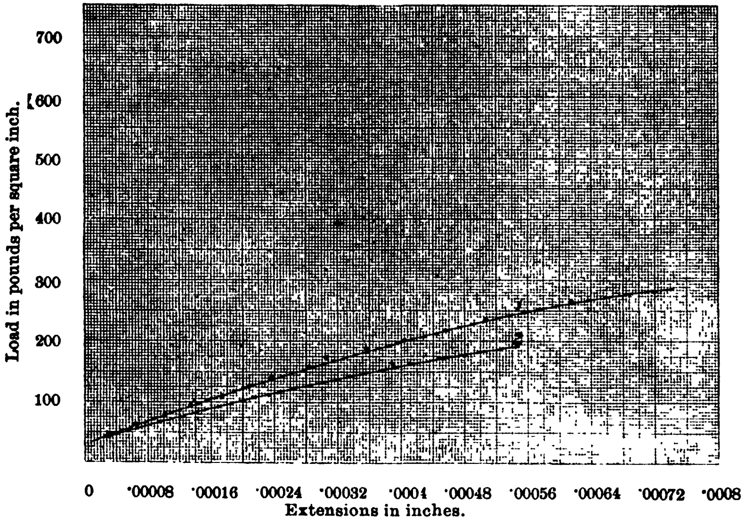


Fig. 5—Tensile Tests of Mortar Briquettes, Age 6 months.
No. 1—One Hemmoor Cement to three Emu Plains sand.
No. 2— „ „ four „ „

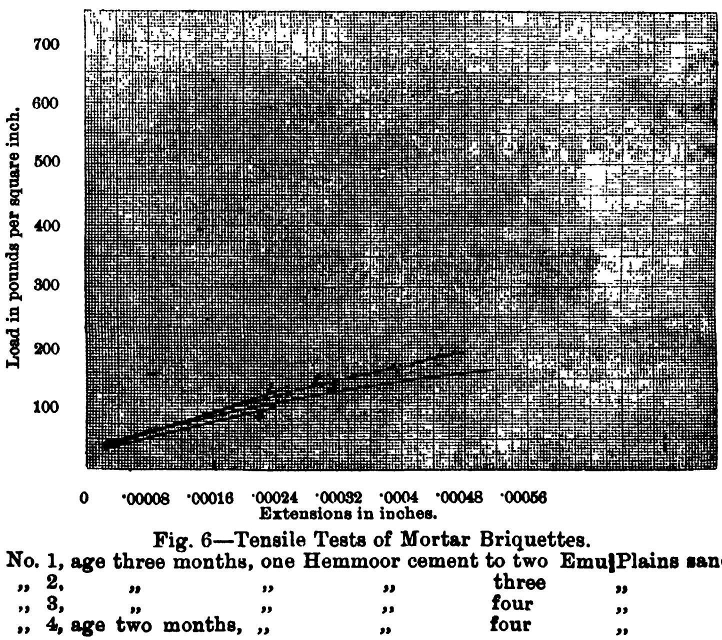


Fig. 6—Tensile Tests of Mortar Briquettes.
No. 1, age three months, one Hemmoor cement to two Emu Plains sand.
„ 2, „ „ „ three „
„ 3, „ „ „ four „
„ 4, age two months, „ „ four „

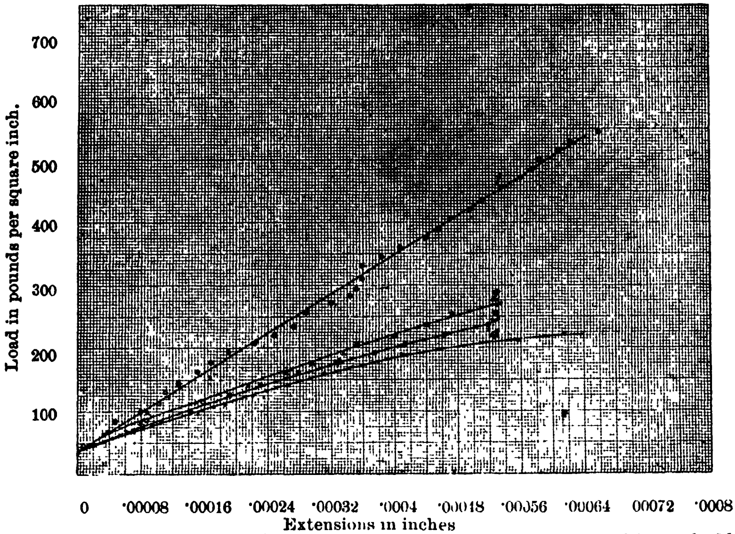


Fig. 7—Tensile Tests of Mortar Briquettes, containing steel bars, half inch diameter. Age 28 days.

No. 1—One Hemmoor cement to three Emu Plains sand; five bars.
„ 2— „ „ „ „ „ four „
„ 3— „ „ „ „ „ four „
„ 4— „ „ „ „ „ one „

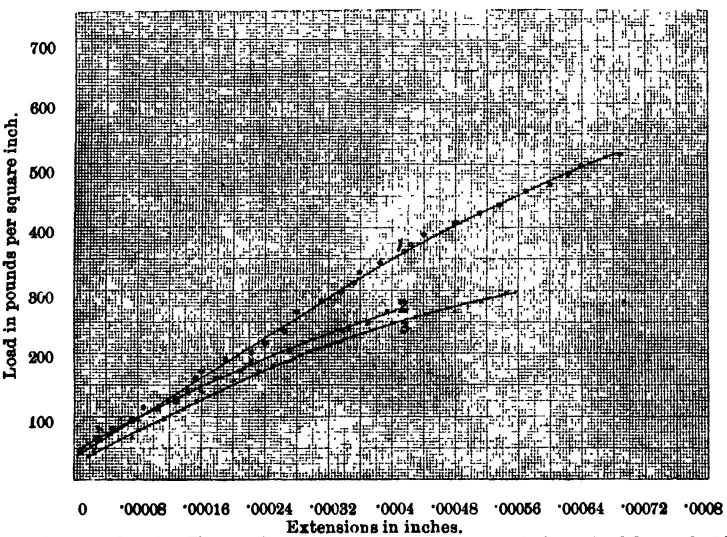


Fig. 8—Tensile Tests of Mortar Briquettes, containing steel bars, half inch diameter. Age 90 days.

No. 1—One Hemmoor cement to three Emu Plains sand; five bars.
„ 2— „ „ „ „ one „
„ 3— „ „ „ „ four „

in tension reinforced with bars of Bessemer steel at ages of from 28 days to 90 days.

Comparing the deformations and breaking weight of a test piece reinforced with a plain test piece not reinforced, it will be seen that the increase in strength is very marked in the case of the piece reinforced with five bars, being about 2·3 times that of the plain pieces. The increase with four bars is very small compared with the increase with one bar. The decrease in extensibility, and therefore the increase in the coefficient of elasticity is also disproportionately low with the four bar reinforcement, probably due to the centre of the specimen being relatively weaker than the exterior. The results are summarised in the following table :—

Table III.—Showing the stresses producing deformations expressed as multiples of 0·00004 of an inch in reinforced tension pieces compared with similar pieces not reinforced. Mortar aged 3 months, 1 cement to 3 sand.

Extension in 0·00004 inch.	Plain, lb. per sq inch.	Reinforced lb. per sq. inch.		
		[·]	[::]	[:·:]
1	48	70	50	65
5	109	148	150	193
10	175	269	227	330
11	184	296	250	353
14			279	421
16				481
Breaking stress	219	281	301	516

The extensions are reduced in consequence of the adhesion of the mortar to the steel rods. In every case the instantaneous coefficient of elasticity diminishes as the load increases, the curve being convex to the axis of stresses but the reinforced are slightly flatter than the plain pieces, the five bar reinforcement curve being practically straight.

Compression Tests.—The compression tests were made on prisms 12 inches long by 6 inches by 6 inches (Fig. 9),

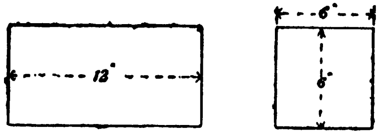


Fig 9

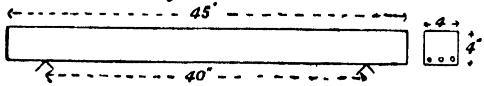


Fig 14

and the shortenings of the prisms under compressive stress were measured by means of the Martens' mirror apparatus in a similar manner to that described in the tension tests (Fig. 10). The tests were all made in a vertical

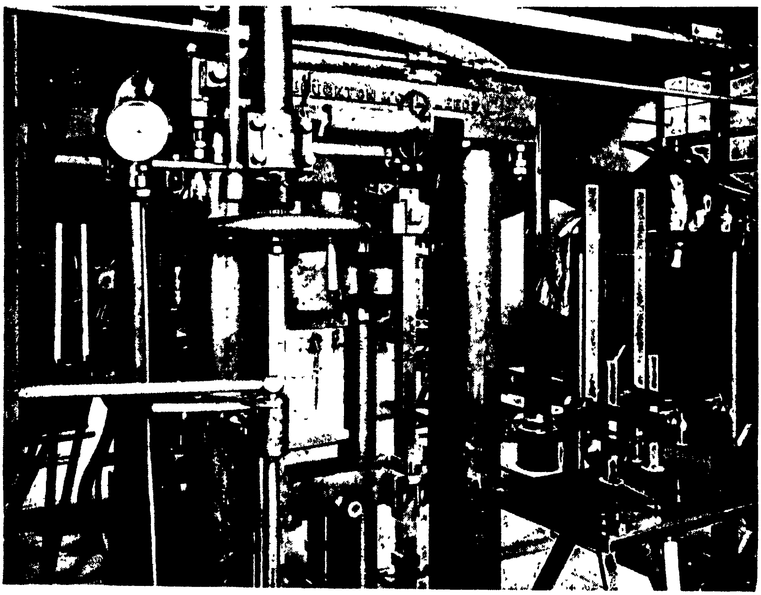


Fig. 10—Shewing Compressive Test Piece in large Testing Machine with Martens' Mirrors attached.

testing machine, and the prisms were of similar composition in regard to Portland cement and sand as in the tension tests. The results are recorded in Table IV. and in figs. 11 to 13.

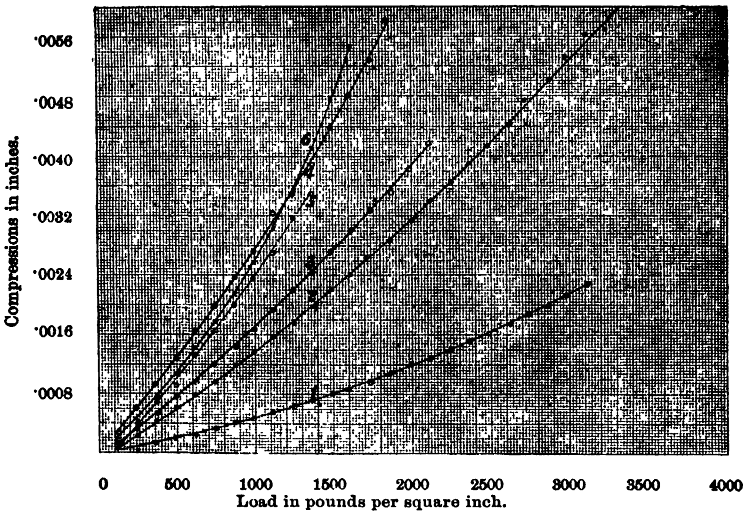


Fig. 11—Compressive Tests of Mortar Prisms.

No. 1—One Hemmor Cement to two Emu Plains sand; age 380 days.
„ 2— „ „ „ „ „ „ 381 „
„ 3— „ „ three „ „ „ 423 „
„ 4— „ „ „ „ „ „ 379 „
„ 5— „ „ four „ „ „ 416 „
„ 6— „ „ „ „ „ „ 421 „

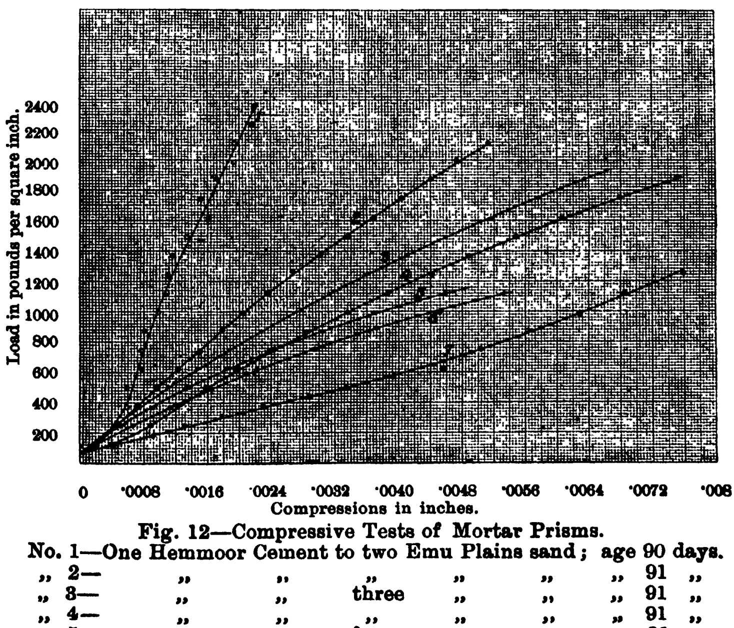


Fig. 12—Compressive Tests of Mortar Prisms.

No. 1—One Hemmoor Cement to two Emu Plains sand; age 90 days.
„ 2— „ „ „ „ „ „ 91 „
„ 3— „ „ three „ „ „ 91 „
„ 4— „ „ „ „ „ „ 91 „
„ 5— „ „ four „ „ „ 91 „
„ 6— „ „ „ „ „ „ 91 „

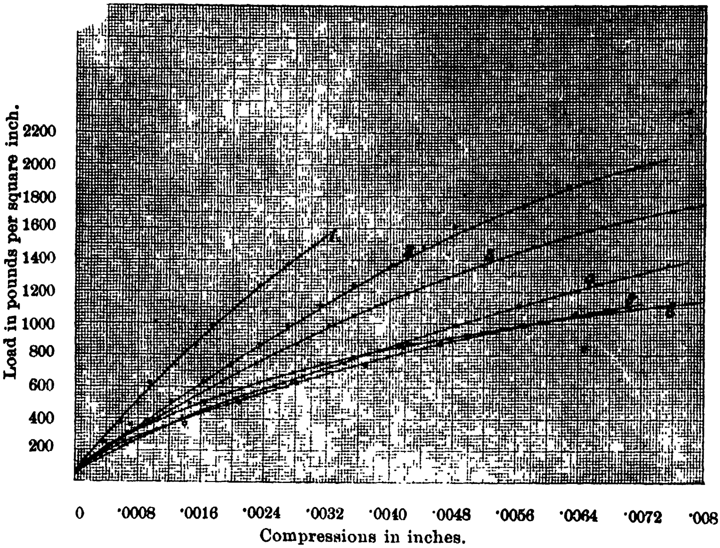


Fig. 13—Compressive Tests of Mortar Prisms.

No. 1—	One Hemmoor Cement	to	two	Emu Plains	sand;	age 28 days.
,, 2—	,,	,,	,,	,,	,,	,,
,, 3—	,,	,,	three	,,	,,	,,
,, 4—	,,	,,	,,	,,	,,	age 29 days.
,, 5—	,,	,,	four	,,	,,	,, 28 ,,
,, 6—	,,	,,	,,	,,	,,	,, 29 ,,

The diagrams show smooth curves, but in fig. 11 the curves are slightly concave to the axis of stress, whereas in fig. 12 some of the diagrams are slightly convex; again, in fig. 13 they are all convex to the stress axis as in the tension tests. The coefficient or modulus of elasticity is not so regular as in the tension tests, but it is much greater than the corresponding modulus in tension. The coefficient of elasticity increases with the age and richness of the mixture.

Transverse Tests.—The first series consisted of eight beams 45 inches long by 4 inches by 4 inches of Portland cement mortar, made with 1 part of cement and 3 parts of standard sand, similar to that used in the tensile and compressive tests. The beams were all tested on a span of

45 inches, loaded in the centre (Fig. 14); the deflections produced by the various loads were measured by means of sector deflectometers, reading to $\frac{1}{50}$ mm. directly, or $\frac{1}{1250}$ of an inch, attached to each side of the beam in the centre. Four beams were tested when reinforced with steel rods half inch in diameter on the tension side, and four were tested without any reinforcement in order to compare the one with the other.

The results are recorded in Tables V. and VI., and in figs. 15 and 16, from which it will be seen that the strength

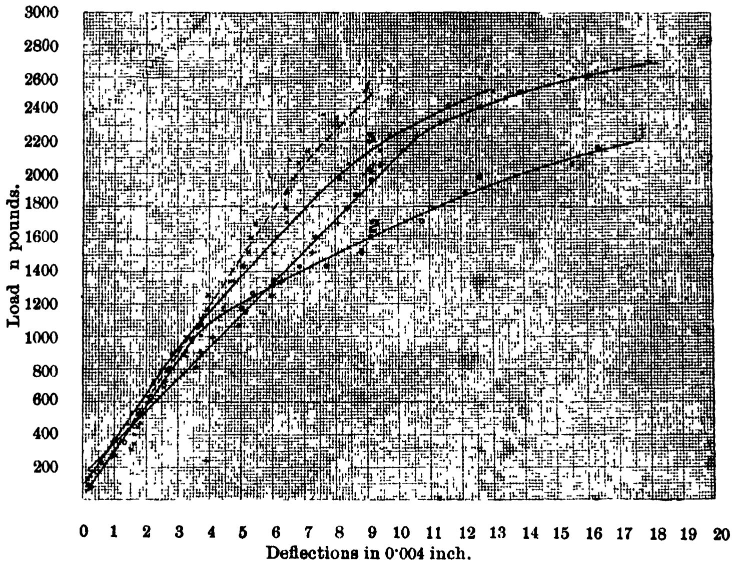


Fig. 15—Transverse Tests of Mortar Beams, containing three half inch steel bars.

No. 1—One Hemmoor Cement to three Emu Plains sand; age 159 days
„ 2— „ „ „ „ „ „ 161 „
„ 3— „ „ „ „ „ „ 187 „
„ 4— „ „ „ „ „ „ 192 „

is increased by the steel rods from $5\frac{1}{2}$ to 10 times that of the plain beams not reinforced. Again, the reinforced beams are able to deflect much more than the plain beams without fracture.

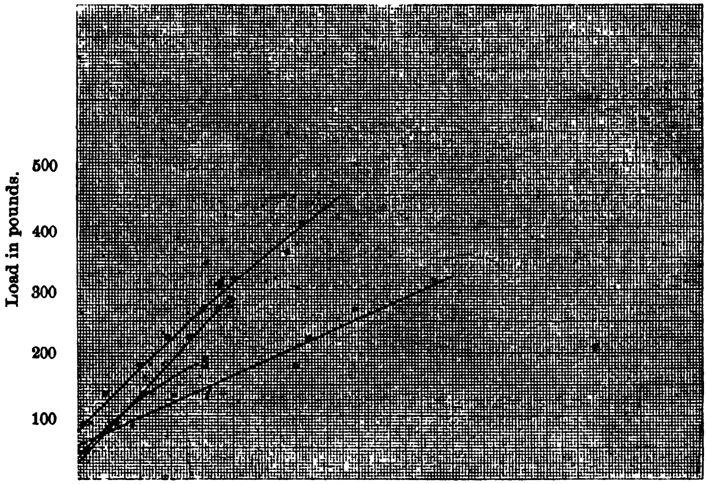


Fig. 16—Transverse Tests of Mortar Beams.

No. 1—One Hemmoor Cement to three Emu Plains sand; age 94 days
,, 2— ,, ,, ,, ,, ,, ,, 154 ,,
,, 3— ,, ,, ,, ,, ,, ,, 180 ,,
,, 4— ,, ,, ,, ,, ,, ,, 188 ,,

A second series consisted of five mortar beams of similar composition to that just described and tested in a similar manner; the span was 48 inches and each beam was reinforced with four rods $\frac{3}{8}$ inch in diameter arranged on the tension side, giving an area of 0·4416 square inches. The width remained constant throughout the series, namely 9 inches, but the depth varied from 12 inches to 2 inches. The results are recorded in Table VII. and fig. 17.

These beams gave a modulus of rupture which decreased as the depth was diminished, being 1,055 pounds per square inch for the 12 inches depth, and 3,500 pounds per square inch for the 2 inches depth, whereas the modulus of elasticity increased as the depth was diminished, being about three and a half times as great in the 4 inches depth as in that of the 12 inch depth. The modulus of elasticity

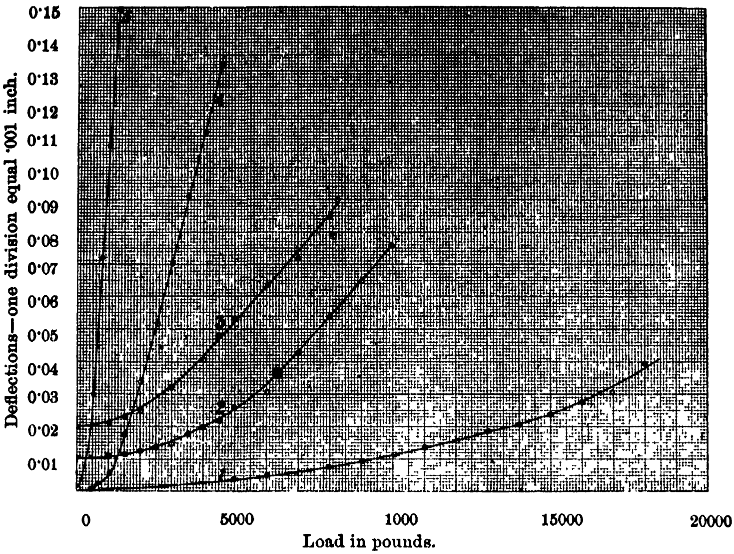


Fig. 17—Transverse Tests of Mortar Beams, containing three-eighth inch iron rods.

No. 1—1	Hemmoor Cement	to	3	Nepean R. sand;	9 × 12 in.,	age	80 days.
„ 2—1	„	„	3	„	9 × 8 in.,	„	86 „
„ 3—1	„	„	3	„	9 × 6 in.,	„	94 „
„ 4—1	„	„	3	„	9 × 4 in.,	„	99 „
„ 5—1	„	„	3	„	9 × 2 in.,	„	102 „

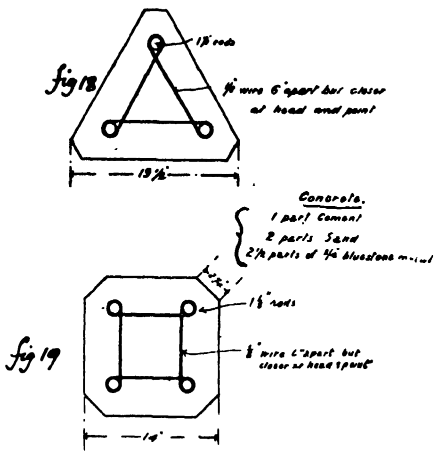
decreased in every case as the load was increased, as in the foregoing series.

A series of three tests were made in order to show the transverse strength of concrete piles when reinforced with steel, for the Sydney Harbour Board. The cross section of one of the piles was triangular, the sides of which were $19\frac{1}{2}$ inches, the steel rods arranged at each corner were $1\frac{1}{3}$ inch in diameter, tied every 6 inches with wire $\frac{1}{8}$ inch in diameter (see fig. 18). The pile was supported at each end of the span of 5 feet $6\frac{1}{2}$ inches and loaded in the centre. The second pile was of square section, 14 inches by 14 inches (Fig. 19) made and tested in a similar manner on a span of 5 feet $6\frac{1}{2}$ inches. The third pile was similar in section to fig. 16, but it was tested on a span of 15 feet. The con-

Sydney Harbour Trust

Monier Piles

Scale 1½" = 1 Ft.



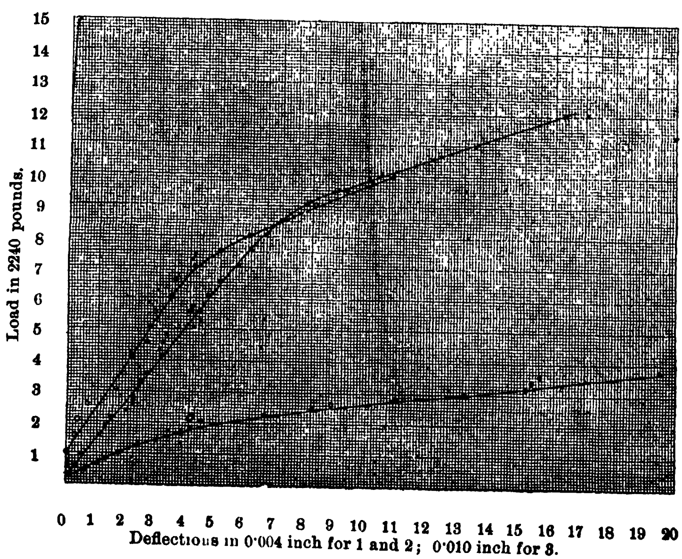


Fig. 20.

crete consisted of one part of Portland cement, two parts of sand, and two and a half parts of broken blue metal $\frac{3}{4}$ gauge. The results are recorded in Table VIII. and fig. 20.

The triangular pile showed about the same modulus of rupture as the square pile on a span of 5 feet $6\frac{1}{2}$ inches, but the square pile tested on a span of 15 feet was 50% stronger than a similar pile tested on a span of 15 feet, due probably to the more complete distribution of the stress in the longer pile.

In the experiments recorded in Tables I. to VI. the specimens were removed, after hardening in air for 24 hours, into water where they were kept until they were taken out for testing. The experiments recorded in Tables VII. and VIII. were allowed to harden in air.

The author proposes to read a paper early next year dealing with the application of these results to the design of reinforced mortar and concrete constructions, and he wishes to acknowledge the assistance of Mr. A. Boyd, B.Sc., B.E., in connection with the testing and recording of the results.

Table I.—TENSILE TESTS OF MORTAR BRIQUETTES.

Composition.	Age in months.	Total load applied.	Tensile stress, lbs per sq. in.	Elongations ·00004 inches.	Coefficients of Elasticity, lbs. per sq. inch.	Breaking load lbs. per sq. in.
1 cement to 3 sand	12	1000	62	1·0	3125000	281
		2150	134	5·0	2062500	
		3550	222	10·0	1906250	
		4220	262	13·0	1781250	
	6	800	50	1·0	1875000	281
		1940	121	5·0	1800000	
		3225	201	10·0	1703000	
		4500	281	18·0	1385000	
	3	775	48	1·0	1718750	219
		1750	109	5·0	1562500	
		2800	175	10·0	1437500	
		2950	184	11·0	1393750	
1 cement to 2 sand	12	900	56	1·0	2500000	319
		2350	147	5·0	2312500	
		3875	242	10·0	2110000	
		5100	319	16 0	1797000	
	3	775	48	1·0	1718750	296
		1800	112	5·0	1625000	
		2050	128	6·0	1612500	
1 cement to 4 sand	12	950	59	1·0	2812500	234
		1900	119	5·0	1750000	
		3030	190	10·0	1593750	
		3500	219	14·0	1387500	
	6	800	50	1·0	1875000	187
		1660	104	5·0	1450000	
		2800	175	10·0	1437500	
		2725	170	12·0	1156250	
	3	825	51	1·0	2031250	187
		1660	104	5·0	1450000	
		2400	150	10·0	1187500	
		2500	156	11·0	1137500	
	2	700	44	1·0	1250000	142
		1525	95	5·0	1281250	
		1670	104	6·0	1218750	

Table II.

Composition	Age in days.	Total load in pounds.	Tensile stress in pounds per sq inch.	Extensions ·00004 inches.	Coefficients of Elasticity in lbs per sq. in	Breaking load lbs. per sq. in.
1 cement to 3 sand	28	912	57	1·0	2575000	244
		2048	128	5·0	1935000	
		3120	195	10·0	1637500	
		3568	223	12·0	1597900	
1 cement to 3 sand	28	1072	67	1·0	3575000	285
		2240	140	5·0	2175000	
		3472	217	10·0	1857500	
		4048	253	12·0	1847000	
1 cement to 3 sand	28	1088	68	1·0	3675000	575
		3104	194	5·0	3255000	
		5552	347	10·0	3157500	
		8592	537	16·0	3160800	
1 cement to 3 sand	28	880	55	1·0	2375000	218
		1920	120	5·0	1775000	
		2960	185	10·0	1537500	
		3520	220	16·0	1179600	
1 cement to 3 sand	90	800	50	1·0	1875000	301
		2400	150	5·0	2375000	
		3632	227	10·0	1957500	
		4464	279	14·0	1769600	
1 cement to 3 sand	90	1040	65	1·0	3375000	516
		3088	193	5·0	3235000	
		5280	330	10·0	2987500	
		7696	481	16·0	2810900	
1 cement to 3 sand	90	1120	70	1·0	3875000	281
		2368	148	5 0	2335000	
		4304	269	10 0	2379000	

Table IV.

Composition.	Age in days.	Compressive stress in lbs per sq inch.	Compression ·0008 inch.	Coefficient of Elasticity in lbs per sq. inch.	Breaking load lbs. per sq. in.
1 cement to 2 sand	28	410	0·75	4640000	2985
		905	2·00	4215000	
		1650	4·00	3970000	
	28	285	0·75	2973300	2923
		620	2·00	2790000	
		1120	4·00	2645000	
		1560	6·00	2496600	
		1993	9·00	2145500	
	91	315	0·75	3373300	3557
		795	2·00	3665000	
		1450	4·00	3470000	
		2130	6·50	1643000	
	381	360	0·50	5960000	4640
		1140	2·00	5390000	
		2020	4·00	4895000	
		3320	7·50	4344000	
1 cement to 3 sand	28	280	0·75	2906600	2196
		560	2·00	2490000	
		970	4·00	2270000	
		1305	6·00	2071600	
		1730	9·75	1710900	
	29	220	0·75	2106600	2003
		440	2 00	1890000	
		720	4·00	1645000	
		980	6·00	1530000	
		1360	9 50	1366000	
	91	320	0·75	3440000	2923
		660	2·00	2990000	
		1135	4·00	2682500	
		1540	6·00	2463000	
		1925	8·25	2258000	
	91	130	0·75	906600	2643
		505	2·00	2215000	
		955	4·00	4165000	
		1345	6·00	3207500	
		1855	9·25	2988300	
	423	280	0·50	4360000	2115
		940	2·00	4390000	
		1710	4·00	4120000	
		2115	5·25	3910400	
	379	160	0·50	1960000	3129
		610	2·00	2740000	
		1140	4·00	2695000	
		1860	7·25	2480000	

Table IV.—*continued.*

Composition.	Age in days.	Compressive stress in lbs. per sq inch	Compression ·0008 inch.	Coefficient of Elasticity in lbs per sq. inch.	Breaking load lbs per sq. in.
1 cement to 4 sand	29	280	0·75	2906600	1356
		500	2·00	2190000	
		750	4·00	1720000	
		920	6·00	1430000	
		1120	9·50	1113600	
	28	225	0·75	2140000	1468
		440	2·00	1890000	
		685	4·00	1557400	
		895	6·00	1388300	
		1095	8·50	1215300	
	91	230	0·75	2240000	1841
		480	2·00	2090000	
		800	4·00	1845000	
		1100	6·50	1597000	
	91	400	0·75	4506600	1692
		560	2·00	2490000	
		900	4·00	2095000	
		1150	6·00	1813000	
	416	260	0·50	3960000	2096
		720	2·00	3290000	
		1325	4·25	2971000	
	421	200	0·50	2760000	2333
		680	2·00	3090000	
		1160	4·00	2745000	
		1605	6·75	2286000	

Table V.—TRANSVERSE TESTS OF MORTAR BEAMS, 4 inches by 4 inches, containing 1 cement to 3 sand and 3 bars of ½ inch steel.

Age in days.	Load in pounds	Readings of Sectors. Front 0·2 mm.	Diff. 0·2mm	Back 0·2 mm.	Diff 0·2mm	Deflections per ·01 ton Mean 0·1 mm	Total deflection 0·1 mm.	Modulus of Elasticity pounds per square inch.	Breaking Load, pounds.	Modulus of rupture pounds per square inch
159	22	12·85	0·00	35·00	0·00	0·00			2890	2737
	45	12·85	0·00	35·00	0·00	0·00				
	89	12·85	0·00	35·00	0·00	0·00				
	134	12·65	0·20	35·05	0·05	0·25	0·25			
	179	12·55	0·10	35·11	0·06	0·16	0·41			
	224	12·45	0·10	35·22	0·11	0·21	0·62	4461600		
	269	12·25	0·20	35·38	0·16	0·36	0·98			
	314	12·15	0·10	35·82	0·44	0·54	1·52			
	358	12·15	0·00	35·92	0·10	0·10	1·62			
	403	12·15	0·00	35·93	0·01	0·01	1·63			
	448	12·15	0·00	36·06	0·13	0·13	1·76			
	538	12·15	0·00	36·10	0·04	0·04	1·80			
	627	12·15	0·00	36·32	0·22	0·22	2·02			
	717	12·15	0·00	36·53	0·21	0·21	2·23			

Table V.—*continued*

Age in days.	Load in pounds	Readings of Sectors. Front 0·2 mm.	Diff. 0·2 mm	Back 0·2 mm.	Diff. 0·2 mm	Deflections per 01 ton. Mean 0 1 mm.	Total deflection 0 1 mm.	Modulus of Elasticity pounds per square inch.	Breaking Load, pounds.	Modulus of rupture pounds per square inch.
	806	12·05	0·10	37·01	0·48	0·58	2·81			
	890	12·05	0·00	37·39	0·38	0·38	3·19			
	986	12 05	0·00	37·50	0·11	0·11	3·30			
	1075	12·05	0·00	37·92	0·42	0·42	3·72			
	1165	12·00	0·05	38·09	0·17	0·22	3·94			
	1254	12·00	0·00	38·12	0·03	0·03	3 97			
	1344	12·00	0·00	38·80	0 68	0 68	4·65			
	1434	12·00	0·00	39·23	0·43	0·43	5·18	4524000		
	1523	12·00	0·00	39·36	0·13	0·13	5·23			
	1613	12·00	0·00	39·43	0·07	0 07	5·30			
	1702	12 00	0 00	39·62	0·19	0·19	5·49			
	1792	12·00	0·00	40·60	0·98	0 98	6 47			
	1882	12·00	0·00	40 63	0·03	0 03	6·50			
	1971	11·95	0·05	40·75	0·12	0·17	6·67			
	2061	11 95	0 00	40 93	0 18	0·18	6·85			
	2150	11·95	0·00	41·20	0·27	0·27	7·12			
	2240	11·95	0·00	42 20	1·00	1·00	8·12			
	2330	11·95	0·00	42 82	0·62	0 62	8·74	4301200		
161	0	16 00	0·00	33·94	0·00	0·00	0·00		2240	2128
	89	16·00	0·00	34·12	0·18	0·18	0·18			
	179	16 00	0·00	34·42	0·30	0·30	0 48			
	269	16·00	0·00	34·85	0·43	0·43	0 91	4680090		
	358	16·00	0·00	35·26	0 41	0·41	1 32			
	448	16·00	0 00	35·55	0 29	0·29	1·61			
	538	15·95	0·05	35·62	0 07	0·12	1 73			
	627	15·95	0·00	35·85	0·23	0·23	1·96			
	717	15 95	0·00	36 42	0 57	0·57	2·53			
	806	15·95	0·00	36·60	0 18	0·18	2·76			
	896	15·95	0·00	36·70	0·10	0·10	2·81			
	986	15·55	0·00	37·32	0·62	0·62	3·43			
	1075	15·45	0·10	37·42	0·10	0·20	3·63			
	1165	14·75	0·70	38·10	0·68	1·38	5·01			
	1254	14 55	0·20	38·28	0·18	0·38	5·39			
	1344	14·25	0·30	38·61	0·33	0·63	6 02			
	1434	13 45	0·80	39·50	0·89	1·69	7·72	3088800		
	1523	12·85	0·60	40 05	0·55	1·15	8 86			
	1613	12·70	0·15	40·20	0·15	0·30	9·16			
	1702	11·90	0·80	41·00	0·80	1·60	10·76			
	1792	11·85	0·05	41·25	0·25	0 30	11·16			
	1882	11·10	0 75	42·60	0·35	1·10	12·16			
	1971	10·90	0·20	42·85	0·25	0·45	12·61			
	2061	9·35	0·55	44·21	1·36	2 91	15·52			
	2150	9 25	0·10	44·95	0·74	0·84	16·36	3012400		
187	22	15·45	0·00	33·85	0 00	0·00	0·00		2598	2464
	89	15·44	0·01	33·86	0·01	0·02	0·02			
	179	15·20	0·24	33·86	0 00	0·24	0·26			
	269	15·00	0·20	33·86	0 00	0·20	0·46	6505200		
	358	14·25	0·75	33·86	0·00	0·75	1·21			
	448	14·00	0·25	33·88	0·02	0·27	1·48			

Table V.—*continued.*

Age in days.	Load in pounds.	Readings of Sectors. Front 0·2 mm.	Diff. 0·2mm	Back 0·2 mm.	Diff 0·2mm	Deflections per 0·1 ton. Mean 0·1 mm	Total deflection 0·1 mm	Modulus of Elasticity pounds per square inch.	Breaking Load, pounds.	Modulus of rupture pounds per square inch.
	538	13·95	0·05	33·89	0·01	0·06	1·54			
	627	13·28	0·67	33·89	0·00	0·67	2·21			
	717	13·22	0·06	33·90	0·01	0·07	2·28			
	806	13·00	0·22	33·90	0·00	0·22	2·50			
	896	12·24	0·76	33·90	0·00	0·76	3·26			
	986	11·79	0·45	33·90	0·00	0·45	5·71			
	1075	11·78	0·01	33·90	0·00	0·01	3·72			
	1165	11·03	0·75	33·90	0·00	0·75	4·47			
	1254	11·00	0·03	33·90	0·00	0·03	4·50			
	1344	10·72	0·28	33·91	0·01	0·29	4·79			
	1434	10·40	0·32	33·91	0·00	0·32	5·11	3931200		
	1523	9·49	0·91	33·91	0·00	0·91	6·02			
	1613	9·38	0·11	33·91	0·00	0·11	6·13			
	1702	9·06	0·32	33·91	0·00	0·32	6·45			
	1792	8·25	0·81	33·91	0·00	0·81	7·26			
	1882	8·07	0·18	33·91	0·00	0·18	7·44			
	1971	7·38	0·69	33·91	0·00	0·69	8·13			
	2061	7·08	0·30	33·91	0·00	0·30	8·43			
	2150	6·07	1·01	33·91	0·00	1·01	9·44			
	2240	5·82	0·25	33·91	0·00	0·25	9·79			
	2330	5·55	0·27	33·91	0·00	0·27	10·06			
	2419	3·92	1·63	33·91	0·00	1·63	11·69			
	2509	2·60	1·32	33·91	0·00	1·32	13·01	2995200		
	22	15·20	0·00	31·16	0·00	0·00	0·00		2777	2631
192	89	15·20	0·00	31·17	0·01	0·01	0·01			
	179	15·10	0·10	31·31	0·14	0·24	0·25			
	269	15·00	0·10	31·50	0·19	0·29	0·54	6474000		
	358	14·85	0·15	31·82	0·32	0·47	1·01			
	448	14·62	0·23	32·35	0·53	0·76	1·77			
	538	14·60	0·02	32·43	0·08	0·10	1·87			
	627	14·50	0·10	32·60	0·17	0·27	2.14			
	717	14·35	0·15	32·90	0·30	0·45	2.59			
	806	14·05	0·30	33·60	0·70	1·00	3.59			
	896	14·00	0·05	33·70	0·10	0·15	3.74			
	986	13·95	0·05	34·00	0·30	0·35	4.69			
	1075	13·95	0·00	34·86	0·86	0·86	4.95			
	1165	13·85	0·10	34·94	0·08	0·18	5.13			
	1254	13·75	0·10	35·70	0·76	0·86	5.99			
	1344	13·70	0·05	35·95	0·25	0·30	6.29			
	1434	13·65	0·05	36·50	0·55	0·60	6.89	3432000		
	1523	13·65	0·00	36·88	0·38	0·38	7.27			
	1613	13·65	0·00	37·00	0·12	0·12	7.39			
	1702	13·65	0·00	37·70	0·70	0·70	8.09			
	1792	13·65	0·00	38·00	0·30	0·30	8.39			
	1882	13·65	0·00	38·28	0·28	0·28	8.67			
	1971	13·65	0·00	38·75	0·47	0·47	9.14			
	2061	13·60	0·05	39·00	0·25	0·30	9.44			
	2150	13·55	0·05	39·68	0·68	0·73	10.17			
	2240	13·55	0·00	40·11	0·43	0·43	10.60			
	2330	13·40	0·15	40·70	0·59	0·74	11.34			
	2419	12·80	0·60	41·42	0·72	1·32	12·66			
	2509	12·20	0·60	42·10	0·68	1·28	13·94			
	2598	11·20	1·00	43·20	1·10	2·10	16·04			
	2688	10·30	0·90	44·15	0·95	1·85	17·89	2340000		

Table VI.—TRANSVERSE TESTS OF MORTAR BEAMS, 4 inches by 4 inches, containing 1 cement to 3 sand.

Age in days.	Load in pounds	Readings of Sectors, Front 0·2 mm.	Diff. 0·2mm	Back 0·2 mm	Diff. 0·2mm	Deflections per 01 ton. Mean 0·1 mm	Total deflection 0·1 mm	Modulus of Elasticity pounds per square inch.	Breaking Load, pounds.	Modulus of rupture pounds per square inch.
94	45	10·00	0·00	28 00	0·00	0·00	0·00		358	359
	89	9·96	0·04	28 04	0·04	0 08	0·08	2059200		
	134	9·73	0·23	28 35	0·31	0·54	0·62			
	179	9·25	0·48	28·65	0·30	0·78	1·40			
	224	9·20	0·05	28·68	0·03	0 08	1·48			
	269	9·04	0·16	28·82	0·14	0·30	1·78			
	314	8·78	0·26	29·06	0·24	0·50	2·28	1794000		
154	0	14·92	0·00	30·00	0·00	0·00	0·00		336	338
	45	14·91	0·01	30·05	0·05	0·06	0·06			
	89	14·90	0·01	30·23	0·18	0·19	0·25	4212000		
	134	14·90	0·00	30 41	0·18	0·18	0·43			
	179	14·90	0·00	30·55	0·14	0·14	0·57			
	224	14·90	0·00	30 70	0·14	0·15	0·72			
	269	14·90	0·00	30·89	0·19	0·19	0 99	3822000		
180	0	14·90	0·00	28·31	0 00	0·00	0·00		224	327
	45	14·95	0·05	28·46	0·15	0·10	0·10			
	89	14·86	0·09	28·47	0·01	0·10	0·20	3900000		
	134	14·75	0·11	28·60	0·13	0 24	0·44			
	179	14·59	0·16	28·76	0·16	0·32	0·76	2964000		
188	22	16·18	0·00	31·46	0 00	0·00	0 00		403	401
	45	16·17	0·01	31·48	0·02	0·03	0 03			
	89	16·18	0·01	31·49	0·01	0·00	0 03	3900000		
	134	16·10	0·08	31·56	0·07	0 15	0·18			
	179	16·00	0·10	31·68	0·12	0·22	0·40			
	224	15·92	0·08	31 78	0·10	0·18	0·58			
	269	15·80	0·12	31·89	0·11	0·23	0·81			
	314	15·66	0·14	32·00	0·11	0·25	1·06			
	359	15·55	0·11	32·18	0·18	0·29	1·35			
	404	15·78	0·13	32·40	0 22	0 09	1·44	3525600		

Table VII.—TRANSVERSE TESTS OF MORTAR BEAMS, containing Iron Bars. Span 4 feet.

Description.	Age in days	Load in pounds	Scale differences in inches	Total deflection in inches	Modulus of Elasticity in pounds per square inch	Breaking Load, pounds	Modulus of Rupture, pounds per square inch
One cement to three Nepean River sand Four ⅜ inch iron bars; 9 inches wide 12 inches deep.	80	5000	0 00	·004		19000	1055
		6000	0 001	005	2133000		
		7000	0·001	·006			
		8000	0 002	008			
		9000	0·002	·010			
		10000	0 002	·012			
		11000	0 002	·014			
		12000	0 002	016	1333000		
		13000	0 003	·019			
		14000	0 002	·021			
		15000	0·003	·024			
		16000	0 004	028			
		17000	0 003	·031			
		18000	0 009	040	800000		
		19000	0 009	099			
One cement to three Nepean River sand Four ⅜ inch iron bars; 9 inches wide 8 inches deep.	86	1000	0 00	001		11000	1375
		1500	0 001	002	4500000		
		2000	0 001	003			
		2500	0 001	004			
		3000	0·001	·005			
		3500	0 002	007			
		4000	0 003	010	2400000		
		4500	0 002	012			
		5000	0 004	016			
		6000	0 005	021			
		7000	0 012	033			
		8000	0 011	044			
		9000	0 011	055			
		10000	0 011	066	909000		
		11000					
One cement to three Nepean River sand Four ⅜ inch iron bars; 9 inches wide 6 inches deep	94	1000	0 00	001		8250	1832
		1500	0·002	003	7111000		
		2000	0 002	005			
		2500	0 003	008			
		3000	0 004	·012			
		3500	0 006	018			
		4000	0 003	021	2708900		
		4500	0 007	028			
		5000	0 005	033			
		6000	0 011	·044			
		7000	0·008	052			
		8000	0 013	065			
		8250	0 005	070	1675700		
One cement to three Nepean River sand Four ⅜ inch iron bars; 9 inches wide 4 inches deep.	99	500	0 000	0 001		5000	2500
		1000	0 005	0 006	8000000		
		1500	0·012	0·018			
		2000	0 016	0 034			
		2500	0 018	0 052			
		3000	0 018	0 070	2057000		
		3500	0 021	0 091			
		4000	0 020	0 111			
		4500	0 021	0·132			
		5000	0 021	0 153	1568000		
		,,	0 007	0 160			
One cement to three Nepean River sand Four ½ inch iron bars, 9 inches wide 2 inches deep.	102	500	0·00	0·032		1750	3500
		750	0 040	0.072	4000000		
		1000	0 035	0 107			
		1250	0 044	0·151			
		1500	0·104	0·255	2258000		
		1750					

Table VIII.—TRANSVERSE TESTS OF MONIER BEAMS.

Description.	Load in pounds.	Sector Readings. Front ·02 cm.	Back ·02 cm.	Sum. ·01 cm.	Diff. ·01 cm	Total deflection ·01 cm.	Modulus of Elasticity, pounds per square inch.	Breaking Load, tons.	Modulus of rupture pounds, per square inch.
Four	560	10·77	1·00	11·77		0 0		28000	813
bars 1⅛	1120	10·94	1·13	12 07	·30	0·3			
inch in	1680	11·05	1 20	12·25	·18	0·48			
diam.	2240	11·50	1·26	12·76	·51	0 99			
Span	2820	11·50	1 30	12·80	·04	1 03			
5 feet	3380	11·50	1·42	12 92	·12	1·15	1316900		
6½ inch.	3940	11·52	1·50	13·02	·10	1·25			
	4480	11·61	1·58	13·19	·17	1·42			
(Fig. 15)	5040	12·04	1·68	13·72	53	1·95			
	5600	12·26	1·72	13·98	·26	2·21			
	6160	12 25	1·81	14 06	·08	2 29			
	6720	12 26	1 90	14·16	·10	2·39			
	7280	12·28	2·00	14·28	·12	2 51			
	7280	12·24	2·24	14·48					
	7840	12·24	2 25	14·49	·01	2·52			
	8400	12·66	2·33	14·99	·50	3·02			
	8960	12 66	2·40	15 06	·07	3 09			
	9520	12·55	2·38	14 93	·13	2·96			
	10080	12·56	2·45	15·01	·08	3·04			
	10640	12·57	2·58	15·15	·14	3 18			
	11200	13 12	2·92	16·04	·89	4·07			
	11760	13·37	2·90	16·27	·23	4 30	1307600		
	12320	13·14	3·15	16·29	·02	4·32			
	12880	13·22	3·16	16·38	·09	4·41			
	13440	13·30	3·24	16·54	·16	4·57			
	14560	13·45	3·50	16·95	·41	4·98			
	15680	13·47	4 05	17·52	·57	5·55			
	16800	14·43	4·50	18·93	·41	5 96			
	17920	14 70	4·70	19·40	·47	6·43			
	19040	15 09	5·00	20 09	·59	7·02			
	20160	15·45	5·40	20·85	·76	7·78			
	21280	15·90	5·90	21·80	·95	8·73			
	22400	16 60	6·65	23 25	1·45	10·18			
	23520	17·80	7·20	25·00	1·75	11·93			
	24640	18·26	8·10	26·36	1·36	13·29			
	25760	18·83	8·80	27·63	1·27	14 56			
	26880	19·76	9·60	29·36	1·73	16·29	1624000		
	28000								
Three	2240	10·97	3·32	14·29		0·0		27552	802
bars.	3380	11·20	3·32	14·52	·33	0·33			
Span	4480	11·23	3 32	14·57	·05	0 38	3299200		
5 feet	5600	11·46	3·37	14·83	·26	0·64			
6½ inch.	6720	12·02	3·86	15 88	95	1·59			
	7840	12·22	3 92	15·14	·26	1·85			
(Fig. 16)	8960	12·48	3·96	16·44	·30	2 15			
	10080	12·82	4·05	16·87	·43	2·58			
	11200	13·51	4·53	18·04	·17	2·75			
	11200	11·90	4·48	16·38					
	12320	11·96	4·54	16·50	·12	2·87			
	13440	12·17	4 85	17·02	·52	3·39	3396100		
					·12				

Table VIII.—*continued.*

Description	Load in pounds.	Sector Readings. Front ·02 cm.	Back ·02 cm.	Sum. ·01 cm.	Diff. ·01 cm.	Total deflection ·01 cm.	Modulus of Elasticity pounds per square inch.	Breaking Load, tons.	Modulus of rupture pounds per square inch
	14560	12 29	4·85	17·14		3·51			
	15680	12 71	5·05	17·76	·62	4·13			
	16800	13·10	5·50	18·60	·84	4·97			
	17920	13·56	6·00	19·56	·96	5·93			
	19040	14·02	6·50	20·52	·96	6·99			
	20160	14·60	6 95	21·55	1·03	8·02			
	21280	15 20	7·40	22·60	1·05	9·07			
	22400	16·03	8·15	24·18	1·58	10·65	1958900		
	23520	16·35	1·51	24·86	0·68				
	24640	16 60	9·50	26·10	2·04				
	27552								
Four bars $1\frac{1}{8}$ inch in diam. Span 15 feet. (Fig. 16)	0	10·92	8·59	19·51		0·0		12432	1226
	448	10·93	8·68	19·61	0·10	0·10			
	896	10·96	9 09	20·15	0·54	0·64			
	1344	11·15	9 40	20·55	0 40	1·04			
	1792	11·16	9·60	20 76	0·21	1·25			
	2240	11·36	9·85	21·21	0·45	1·70	4998000		
	2688	11·69	10·20	21·89	0·67	2·37			
	3136	11·96	10 50	22·46	0·59	2·94			
	3584	12·35	10 93	23 28	0·82	3·76			
	4032	13·00	11·57	23·57	0·29	4·05			
	4480	13 65	12·22	25 87	0·30	4·35			
	4928	13·14	14·92	28·06	0·19	6·54			
	5376	15·62	13 90	29·52	1·46	8·00	3043600		
	5824	15·95	14 28	30·23	0·71	8 71			
	6272	17·15	15·20	32·35	2·12	10·83			
	6720	18·34	16·25	34·55	2·20	13·03			
	7168	19·45	17·12	36·57	2·02	15·05			
	7616	19·55	17·17	36·72	0·15	15·20			
	8064	19·60	17·43	37 03	0·31	15·51			
	8512	21·60	19·58	41·18	4·15	19·66	1654600		
	8960	22·50	20·56	43·00	1·82	21·58			
	12432								

THE FALLACY OF ASSUMING THAT A WET YEAR IN ENGLAND WILL BE FOLLOWED BY A WET YEAR IN AUSTRALIA.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[With Diagram.]

[*Read before the Royal Society of N. S. Wales, December 3, 1902.*]

IT is a widespread idea that if abundant rain falls in England there will be an abundant rainfall in Australia in the following year. If we look at the diagram it is at once evident that such conditions are very irregular, and after carefully examining the same, we cannot but admit that although sometimes heavy rains in England will be followed next year by heavy rains in Australia, it seldom does so. For instance rain was very abundant in England in 1875, likewise in Australia in 1876; the next year England had still more abundant rain but in Australia the rainfall was very much below the previous year, thus contradicting the theory. During 1880 to 1885 inclusive, rain was very abundant in England, while at the same time we were suffering a very severe drought. Again, take the years 1894 to 1901; each one of them shows an abundance of rain in England, while Australia has been suffering a severe drought. Nothing more is needed to justify the fallacy of the statement that an abundant rain in England is followed by an abundant rain in Australia.

IS EUCALYPTUS VARIABLE?

By J. H. Maiden,
Director, Botanic Gardens, Sydney, Government Botanist of New South Wales.

[*Read before the Royal Society of N. S. Wales, December 3, 1902.*]

SYNOPSIS:

I. The variability of characters considered seriatim.
II. Has variation in Eucalyptus now ceased?
III. Some studies in variation.
IV. Mannas, kinos, oils, etc. are accessory characters only.
V. Botanical classification for purposes of nomenclature of genera etc., is based upon morphological characters.

This Journal has been a medium for recording the theory that the genus Eucalyptus has now ceased to be variable. I propose to consider the question from various points of view.

I. The Variability of Characters considered seriatim.

The genus Eucalyptus is such a large one that a number of schemes have been submitted for dividing it into sections with a view of associating those closely allied, or for arriving at the name of a species with facility. I propose to review each character, from timber to anther, to see if any satisfactory scheme can be evolved. In the *Proc. Aust. Assoc. for Adv. of Science*, Sydney Meeting, 1898, both Prof. Tate[1] and Mr. Luehmann[2] simultaneously gave prominence to the use of the fruit for purposes of classification. Both papers take cognizance of other characters as well. Both are the work of men who *know* the genus and are valuable contributions to knowledge.

[1] Tate, R.—"A review of the characters available for the classification of the Eucalypts, with a synopsis of the species arranged on a carpological basis."

[2] Luehmann, J. G.—"A short dichotomous key to the hitherto known species of Eucalyptus."

Habit—Tate defines two habits of growth, viz:—trees, and shrubby, stocky trees, to which he applies the vernacular names of gums and mallees respectively, names well understood in Australia. He points out that in young plants of Eucalypts there is a large inflation of the base of the stem, either at the surface or just below the surface of the soil. In gums (*E. rostrata*, *leucoxylon*, *viminalis*, etc.) this is eventually outgrown, but in the mallees (*incrassata*, *uncinata*, etc.) it persists, and increases in size proportionately with the development of the branches which are emitted from it—in the mallee this rudely globose bole is partly subterranean. "The umbrella-like disposition of the foliage of the taller mallees may be largely incidental to overcrowding, though it would seem to be an inherited character, as it is fairly pronounced in them when they are distinctly separated from one another." This classification is chiefly of practical use in Professor Tate's own State (South Australia) and in Western Australia.

It is however, very difficult to group the species according to habit. Some are dwarf in their typical forms, but under different circumstances they take on a larger growth. Then, speaking generally, such species as are found in damp situations in good soil are umbrageous trees; such for example are *stellulata*, *aggregata*, *Macarthuri*, but this character is largely a matter of environment. Then some species, *e.g.*, *viminalis*, have a more or less drooping habit as a rule, but this species is often nearly erect in less congenial soil. And, further, to show variation in habit, we have only to point to the Eucalyptus plantations of California and the South of France where the species are cultivated almost out of recognition.

Bark—Mueller (*Journ. Linn. Soc.*, III., 99, 1858) arranged the genus in the following six groups in respect to their barks. With the additional information we have obtained

since Mueller's paper was published, we are able to recast his list of examples. It will be found, however, that no two botanists agree as to the sections in which to place some of the species, and as further field-knowledge is available and we know more about variation of bark in the same species, the same authority modifies his own lists.[1]

"1. *Leiophloiæ*—Cortex post delapsum strati supremi undique lævis. (Vulgo, Flooded Gum trees, White Gum trees, Blue Gum trees partim, Red Gum trees partim, Yarra trees)."

Smooth barks ("Gums" we call them). Examples are *E. hæmastoma*, *rostrata*, *tereticornis*, *leucoxylon*, *viminalis*, *Gunnii*, *maculata*, *latifolia*, *aspera*, *stellulata*, *coriacea*, *saligna*, *Behriana*, *punctata*, *stricta*, *fasciculosa*.

"*Hemiphloiæ*—Cortex in trunci parte inferiore persistens rugosus et rimosus, in parte superiore ramisque delapsu strati superiores lævigatus. (Vulgo, Moreton Bay Ash, Blackbutted gum tree, Box trees partim)."

Half-barks, the barks of the lower part of the trunk persistent and the upper part smooth. Examples are *E. hemiphloia*, *pilularis*, *bicolor*, *longifolia*, *melliodora*, *amygdalina*, *dives*. The Moreton Bay Ash *(tesselaris)* is better in section 3 or 6.

"3. *Rhytiphloiæ*—Cortex ubique persistens rugosus et rimosus intus solidus. (Vulgo, Bloodwood trees, Box trees partim, Peppermint trees partim)."

With wrinkled persistent bark, rather solid. This is an unsatisfactory group, including heterogenous barks. Mueller intended it to include the Bloodwoods *(corymbosa*, *eximia*, *trachyphloia)*, also *bicolor* (which is better in 2) and *E. microtheca*; *leptophleba*, *ferruginea*. *Odorata*, *robusta*,

[1] See Woolls, "On the classification of the Eucalypts," *Proc. Linn. Soc. N.S.W.*, (2) vi., 60.

botryoides, may be added and also *Stuartiana*, *pulverulenta*, *microcorys*, *acmenioides*, *resinifera*, *polyanthema*, *populifolia*, *piperita*.

Nos. 2 and 3 run into each other, and both of them into No. 4.

"4. *Pachyphloiæ*—Cortex ubique persistens rugosus intus fibrosus. (Vulgo, Stringybark trees)."

"Stringybarks, with persistent, fibrous barks."

A good natural group, including *eugenioides*, *capitellata*, *macrorrhyncha*, *obliqua*, *pilularis*, var. *Muelleriana*, *tetrodonta*.

"5. *Schizophloiæ*—Cortex ubique persistens profunde sulcatus intus solidus. (Vulgo, Ironbark trees)."

"Ironbarks with hard, deeply furrowed barks."

Perhaps the best of all groups. Examples *E. siderophloia*, *paniculata*, *crebra*, *sideroxylon*, *melanophloia*.

"6. *Lepidophloiæ*—Cortex saltem in trunco persistens lamellaris friabilis. (Vulgo, Melaleuca Gum trees, Mica trees)."[1]

With persistent bark on the trunk only, and forming scaly separate pieces. Mueller's examples are *miniata* (*aurantiaca*) *phoenicea*, *peltata* (*melissiodora*), to which I would add *tesselaris*.

The Revd. Dr. Woolls[2] ignores section 6, and it certainly cannot be separately maintained as a section.

The cortical classification separates trees that are closely allied, *e.g.*, *hemiphloia* and *Baueriana*, the first being a

[1] The meaning of this, which is not quite clear as it stands, is explained by the following passage: "The bark of both is very lamellar and friable, outside of a yellowish- or greyish-brown, on fracture partly glittering, and somewhat resembling mica-schist."—Eucalyptographia under *E. phoenicea*.

[2] Proc. Linn. Soc., N.S.W., VI., 709.

half bark and the latter having rough bark to the branchlets. Similarly *E. pilularis*, in its normal form has smooth, while its variety *Muelleriana* has rough branchlets.

It places in justaposition those that are not closely related, as will be observed from the examples given under each section. Prominent examples are (*a*) *E. paniculata*, Sm., and *E. fasciculosa*, F.v.M., and (*b*) *E. sideroxylon*, A. Cunn. and *E. leucoxylon*, F.v.M., respectively nearly alike in leaves, flowers and fruits, but utterly dissimilar in bark and wood.

Absolute anomalies as regards barks are those of Ironbark for *E. stellulata*, *Sieberiana*, and *viminalis*,[3] a box-like bark for *E. tereticornis*, and observers will note many other anomalies within their own experience. At the same time, in careful hands, the bark is the most useful character the forester can employ.

Timber—While the character of a timber is a matter of economic importance, its use in botanical diagnosis is very often overlooked. For many years I have insisted on the examination of the timber wherever possible, and recognition of this character has undoubtedly led to a better understanding of the genus.

Timbers can be classified in different ways, *e.g.*,

1. *Fissility*—Some are fissile, such as Stringybarks (*E. eugenioides*, etc.), Mountain Ash (*E. Sieberiana*), Victorian Blackbutt (*E. regnans*) etc. Others are short in the grain, such as many gums, snapping off like a carrot, while others are tough and interlocked like boxes and ironbarks.

2. *Colour*—In a lecture delivered in 1891 before the Sydney Architectural Association of N.S.W., I divided many of the Eucalyptus timbers into pale hardwoods, subdividing them into three groups, (*a*) hard, interlocked, (*b*) fissile,

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[3] See Luehmann, *op. cit.* page 524.

(c) inferior, such as gums,—which is a useful practical classification. In my "Notes on the Commercial Timbers of New South Wales" (1895), I submitted the classification (1) ironbarks, (2) pale hardwoods, (3) red hardwoods.

1. *Gums*—These timbers are short in the grain, dry to a brown or reddish colour, crack radially in drying, have many gum veins and, as a rule, lack durability. Their barks are smooth, and more or less ribbony. Examples—*stellulata*, *coriacea*, *hæmastoma*, *viminalis*, *Gunnii*. They connect with the "Boxes" (Bastard), and also with the smooth barked members of the Jarrah Group.

2. *Mallees*—Examples—*oleosa*, *Behriana*, *incrassata*. This is a group based on geographical considerations. They are arid country species and connect the "Gums" and "Red Boxes."

3. *Ironbarks*—These are fully described in my "Notes on the Commercial Timbers of New South Wales." They consist of (*a*) *True Ironbarks*, viz., *paniculata*, *siderophloia*, *crebra*, *sideroxylon*; (*b*) *Bastard Ironbarks*, timbers very similar to ironbarks, but the barks belonging to the "Box" Group. They consist of *Boormani* and *affinis*. *Melanophloia* (and perhaps *microtheca*) connects the two groups.

4. *Boxes*—These are tough, interlocked timbers, usually with fibrous bark on the trunk, and may be sub-divided into:—(*a*) Pale, Examples—*hemiphloia*, *melliodora*, *Bosistoana*, *Baueriana*, *populifolia*, *quadrangulata*, *Cambagei*, *goniocalyx*, *tesselaris*, *leucoxylon*, *corynocalyx*, *globulus*. (*b*) Red, Examples—*bicolor*, *microtheca*, *polyanthema*, *odorata*, *fasciculosa*. These two groups include some smooth barks or "gums" but their timbers are provisionally classified with the "Boxes."

(c) Bastard, Examples—*Stuartiana*, *pulverulenta*, *Macarthuri*, *aggregata*. The timber of (c) is inferior and closely resembles that of the gums.

5. *Stringybark Group*—This includes a number of fissile timbers that pass into each other and may be sub-divided as follows :—

(*a*) True Stringybarks—Examples, *eugenioides*, *macrorrhyncha*, *capitellata*, *obliqua*, *Baileyana*.

(*b*) Blackbutts—Examples, *pilularis*, (which absolutely connects with the Stringybarks through its variety *Muelleriana*), *acmenioides*. The most valuable timbers of the group.

(*c*) Peppermints—Examples, *amygdalina*, *regnans*, *dives*, *piperita*; these timbers have gum-veins and are altogether inferior in quality.

Allied to these is the—

6. *Mountain Ash Group*—Fissile timbers usually pale in colour, and with bark not so fibrous as the preceding. Examples, *Sieberiana*, *Planchoniana*, *virgata*, and its varieties *Risdoni*, *cordata*.

7. *Tallow-wood and Spotted Gum*—*E. microcorys* and *E. maculata*, two valuable pale coloured timbers, *suigeneris*.

8. *Bloodwoods*—These have gum-veins and are coarse grained; *corymbosa* is red, and *eximia* and *trachyphloia*, which are pale, connect with *maculata*.

9. *Jarrah Group*—Containing a number of heterogeneous species, and which I name after the best known member. Some have fibrous barks, others are smooth, but they are all deep-red, durable timbers. Examples, *marginata*, *resinifera*, *diversicolor*, *propinqua*, *punctata*, *saligna*, *botryoides*, *robusta*, *tereticornis*, *rostrata*, *longifolia*. This group connects with the Red Boxes.

The timber of the same species varies a good deal according to soil and situation, and our knowledge does not yet enable us to discriminate between some timbers not closely

allied botanically. In other words, a man who professes to discriminate between all species of timber attempts the impossible.

Exudations—In *Proc. Linn. Soc., N.S.W.*, 1890 I proposed examination of the kinos as an aid in the diagnosis of Eucalypts, and I divided them into three groups according to their behaviour in water or alcohol (spirit).

1. *Ruby Group*—Consisting of ruby coloured kinos, soluble in water and alcohol in all proportions. Examples are, all Renantheræ except *microcorys*.

2. *Gummy Group*—Soluble in water, but insoluble in alcohol owing to the gum they contain. Examples, the Ironbarks.

3. *The Turbid Group*—These kinos are soluble in hot water or hot alcohol but deposit sediment on cooling. Examples, most of the Parallelantheræ. This section, however, includes heterogeneous substances and brings together species little allied. It is doubtless capable of further elaboration, but only serves to accentuate variation in the genus.

Some kinos *e.g.*, *E. maculata*, are characteristic in appearance, having an olive-green colour; perhaps also that of *E. corymbosa*, of an intense, almost vermillion colour.

An exudation of less importance is that of *Manna*. A number of species exude saccharine substances from the leaves and, a very few, from the trunk. The list is being added to slowly, but in most cases the mannas are mere scientific curiosities and of little value in a scheme of classification. They include *viminalis*, *Gunnii*, *punctata*, *pulverulenta*, *Stuartiana*.

Petiole—D. McAlpine and J. R. Remfrey, in *Trans. Roy. Soc. Vic.*, 1890, published a paper entitled "The transverse sections of the petioles of Eucalypts as aids in the determination of species."

The method of classification on the comparatively few experiments made is ingenious but of little practical value to us for diagnosis, thousands of sections being required in order to obtain data for generalisation. The paper is however, of more than ordinary value and is well worthy of perusual.

Leaf—(*a*) *Suckers*—De Candolle (*Prodromus* Vol. III., 1828) classified Eucalypts according to the opposite or alternate character of the leaves, a character of special importance at that time since species were often described from seedlings grown in pots. Field observations have, however, shown that all species have opposite leaves in at least an early stage. In seedlings this is best observed, but in many cases suckers show the character quite as well. In a few species *e.g.*, *gamophylla*, this opposite-leaved character persists through life. In many cases the young leaves are broad and become alternate and narrower, with a lanceolate or falcate shape as maturity is reached. Often these young leaves are glaucous, becoming glabrous as growth proceeds. But there is a group in which the seedling and sucker leaves are narrow. Such species include *amygdalina*, *pilularis*, *viminalis*.

The list is however so incomplete that it is impossible at present to use it as a broad basis of classification. For diagnostic purposes I personally use the shape of the young leaf wherever possible; it is an atavistic character and data are accumulating by which we shall be in a better position to interpret it.

The difference between suckers and mature leaves has been studied in Europe for many years, although in Eucalyptus the systematic comparison of such forms is of comparatively recent date. It is of practical importance to the Australian forester, for the reason that the occur-

rence of these young or sucker leaves is so very frequent in the bush.

"When a trunk is injured new shoots make their appearance either from the "eyes" in the stem or from reserve buds of the branches and twigs, or by buds produced from the roots below the ground. The leaves of these shoots or *suckers*, as they are called, differ very much from the stems or branches which have been broken, eaten, cut or frozen off." . . .

Instances of differences are given and it is added, "Hundreds of trees and shrubs might be mentioned in which there is a distinct difference between the foliage of the suckers and of the normal branches of the crown."[1]

Nor has the description of species and varieties from suckers or seedling leaves been confined to writers on Eucalyptus :—

"Gardeners and descriptive botanists have frequently determined and described mutilated plants as other species, hybrids, or varieties. They are neither the one nor the other. The peculiar appearance of the altered members resulting from mutilation is exactly determined beforehand in each species; it is due to the specific constitution of the species, and thus is part of its being. It is not produced by the external influences which lead to the formation of the varieties, but is brought about by the inherent necessity quite independent of the influence of climate and soil."[2]

Practically all the researches on the anatomy of Eucalyptus leaves have been made on those of the readily available *E. globulus*, in which species both sucker and mature leaves are readily available.

The most complete research is the masterly paper of G. Briosi.[3] See also a study by H. Pocklington.[4]

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[1] Kerner and Oliver, II., 515, 6. [2] *Op. cit.*, 518.

[3] Ricerche intorno all' anatomia delle foglie dell' *Eucalyptus globulus*, 23 *pl*. *Milano*, 1892.

[4] The Microscope in Pharmacy, *Eucalyptus globulus*. *Pharm. Journ.* (3) III., 990; IV., 549. A useful histological study of bark, leaves, etc.

Then Henslow[1] says:—"The chief difference between the two forms of leaves I find to be as follows:—In the horizontal leaf the upper epidermis is composed of small cells, and there are no stomata. There is a palisade tissue of one layer of cells, with lax mesophyll below the lower epidermis. This latter has larger cells than the upper and is provided with stomata. The pendulous leaf is a good deal thicker than the horizontal. Both epidermides are provided with a very dense cuticle in which the stomata are deep-seated. There are four rows of palisade cells on both sides with a chlorophyllous mesophyll between them. The petiole is flattened so that the leaf can swing much in the same way as that of the Poplar."

A useful paper by Dr. Albert Schneider[2] speaks of the sucker ("dorsiventral") leaves with palisade cells on the upper side and stomata on the under side only. The mature leaves "isolateral leaves or phyllodes" take a vertical position with the convex edge directed upward. The epidermis is alike on both sides. It will be observed that his results do not agree with those of Henslow,—evidence of variation.

The anatomical characters of the leaves of Eucalyptus offer, however, much room for research. See "stomata" p. 327.

(b) *Cotyledon leaves*—The shape of the cotyledon leaves we know less about, and data are being collected. The work has been hindered because of the difficulty of obtaining seed from certain interesting forms. Mueller's *Eucalyptographia* and Lubbock's "A contribution to our knowledge of seedlings," form the basis of our present available information on the subject.

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[1] Origin of Plant Structures, p. 68 (note). His "horizontal" are sucker leaves and "pendulous" the mature foliage.

[2] Structure of *Eucalyptus globulus* leaves. *Journal of Pharmacology*, IV., 169; *Pharm. Journ.* 28th Aug. 1897, p. 191.

Other characters of Eucalyptus leaves we require to know more about, are their size, texture and prominence of venation. They are minor characters, and some species present much variation in this respect.

(c) *Venation*—Messrs. Baker and Smith[1] have grouped certain Eucalyptus leaves into sections in regard to the disposition of their veins, pointing out that the oil-content of the leaves can in a measure be gauged from the venation. The suggestion is ingenious but as the venation is, like other characters, variable within such large limits, (*e.g.*, in the same twig the lower leaves may have spreading veins, while the upper ones may have a nearly pinnate venation), the method will only be practically useful in the hands of experts.

(d) *Young stems*—Some Eucalypts have marked quadrangular stems. *E.g.*, *globulus*, *Maideni*, *goniocalyx*, *quadrangulata*, *tetragona*, and many others, but, as a rule this quadrangular appearance, often well marked at an early stage of growth, passes away as growth proceeds.

(e) *Essential oil*—The perfume of Eucalyptus leaves is owing to the presence of an oil. It varies in different species in regard to both character or amount. In young it is commonly more abundant than in mature foliage, the high proportion of resinous matter in the young foliage being, however, a drawback to distillation. In some cases the perfume is not easy to define, but the crushing of the fresh or even dried leaves in the warm hand has been used as a diagnostic character for many years. It affords a rough but ready test, which is always available, and really valuable in skilled hands. Incidentally it may be mentioned that some few leaves, *e.g.*, *corymbosa*, contain a substance allied to caoutchouc in their tissues especially in their young state.

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[1] This Journal, xxxv., p. 116.

Some years ago, when Superintendent of Technical Education, I determined to ascertain whether this qualitative test of Eucalyptus odour was capable of leading up to further results. Accordingly I obtained samples of commercial Eucalyptus oils and also watched their distillation in the country, but found, as a general rule, that the various kinds of leaves were not rigidly kept apart. I therefore resolved, with the advice of Dr. T. L. Bancroft of Brisbane and the active co-operation of Mr. Owen Blacket, C.E., Lecturer in Engineering at the Technical College, to erect a model still capable of holding large charges of leaves, and to distil only those leaves obtained by my own collector or through agencies which permitted the origin of the leaves to be precisely checked from a botanical point of view. In this way, and in this way only, could Eucalyptus oils of many species, absolutely true to name, be obtained for research. My transfer to the Botanical Gardens removed me from this domain of botanical technology and the work, thus initiated has been continued and extended by my late assistants Messrs. Baker and Smith.

(*f*) *Stomata*:—Mueller, in Eucalyptographia under *E. pachyphylla* and *E. phoenicea*, has classified some of the Eucalypts according to the number and distribution of the stomata. He styles the leaves,—

1. *Hypogenous* according to the presence of stomata on the under surface only.

2. *Heterogenous* according to their presence on both surfaces, but less numerous above than below.

3. *Isogenous*, when they are present on both surfaces, but approximately equal in number above and below. "This almost equal distillation of the stomata coincides with the similarity of the colour of both sides of the leaves."

Examination of the stomata cannot, however, be used for diagnostic purposes with any degree of certainty, because of the variation in the distribution of the stomata even in the same tree.

Galls—At one time I inclined to the opinion that the shapes of the leaf-galls in Eucalyptus would be a useful character for classification. Mr. W. W. Froggatt, who has of late years been giving special attention to Brachyscelidæ, finds that the same insect frequents so many species that no general grouping of the trees based on their galls can be made.

Inflorescence—Professor Tate points out that the usual form of inflorescence is an umbel which by lengthening of the axis passes to the panicle or corymb. The transition from one to the other is so easy, he goes on to remark, and often exemplified on the same tree, that it is obvious the form of the inflorescence is not reliable as a specific character. Bentham had previously drawn attention to the unsatisfactory character of the arrangement of the inflorescence from the point of view of the systematist.

Naudin's grouping (second memoir) of 56 species (or reputed species) known to him as growing in the gardens of Provence, is mainly based on the inflorescence, but also depends on the fruits and leaves. It doubtless was of local value, but it is based on characters which present so much variation as to preclude its general application. Following is an abstract in *Gardeners' Chronicle*, 7th February, 1891:

Section I. Inflorescence in cymes or axillary umbels.

Capsules longer than the calyx tube.

Capsules shorter than the calyx tube.

(*a*) Cymes three flowered.

Leaves uniform, opposite.

Leaves uniform, alternate.

Leaves of two shapes.

(*b*) Cymes of 3 to 7 or more flowered.

Cymes 7 flowered.

Leaves uniform opposite.

Leaves of two shapes, opposite at first.

Leaves uniform, always alternate.

(c) Cymes or umbels, axillary, more than 7-flowered.
Leaves uniform.
Leaves of two shapes.

Section II. Flowers in terminal panicles or corymbs.

Flowers—With reference to individual flowers there is much variation in the number of flowers in an umbel, and to a less extent in the colour of their filaments. The colour in the vast majority of species is white or cream, but in a few species *e.g.*, *leucoxylon*, *sideroxylon*, *viminalis*, *ficifolia*, *calophylla*, *pyriformis*, it may be pink also. In some species, *e.g.*, *ficifolia*, *miniata*, *phoenicea*, it may be red, even a vermillion or orange-red. In a few species (*e.g.*, *pilularis)* the filaments of dried flowers turn red in course of time.

The pedicel is normally rounded, but owing to compression it is very often strap-shaped as in *botryoides*, and extreme cases are afforded by *obcordata*, and *occidentalis.*

Flower-bud—The shape of the operculum was first used as a classification character by Willdenow in his *Species Plantarum*, 1799. He divided the twelve species then known into two groups, "operculo conico," "operculo hemisphærico.". It is undoubtedly a useful character for the purpose, but variable like everything else about Eucalyptus. *E. tereticornis* is usually looked upon as a species to be diagnosed by its operculum but (*Bull. Herb. Boissier*, 1902, 579), I have shown that this character breaks down completely as between that species and *E. rostrata*. *E. capitellata*, and *E. macrorrhyncha* were at one time separated by their opercula, but they pass into each other as regards those organs. At the same time it will always remain, in the hands of a judicious observer, one of the most practically useful diagnostic characters we have.

Some species possess a double operculum or membraneous bract enveloping the whole of the young inflorescence. It was first observed by Robert Brown (see his description of *Eudesmia tetragona*), but a few years ago it was only recorded from a very few species. In some it is very early deciduous and, in others infrequent, but I have observed it in such a large number of species that I am inclined to the opinion that extended research will show that it occurs in all. Brown's and Jussieu's interesting observations on the single and double operculum will be found supplementary to the former's description of *Eudesmia tetragona* (*Bot. App. to Flinders' Voyage*).

Anther—Bentham (*Flora Australiensis*) first grouped species according to the shape and mode of dehiscence of the anthers. He made five groups, but laid no stress on the importance of the dehiscence of the top on the anther. He however, alludes (B. Fl. iii. 186) to "truncate" anthers, and at page 189 to the truncate anthers of *E. leucoxylon*. Mueller, finding that Bentham's five groups could not be separately maintained, reduced them to three, viz:—

(*a*) *Renantheræ*, the anthers large and the cells divergent at the base.

This section mostly includes the Stringybarks, although it includes several White Gums, plants otherwise very different.

(b) *Porantheræ*, the anthers small an opening in pores.

This section mostly includes Boxes and some Mallees, and includes the Silver-leaved Ironbark (*melanophloia*), while *E. crebra* which is very closely allied to it is placed in another section.

(c) *Parallelantheræ*, the cells parallel, and the longitudinal slits consequently parallel.

This section comprises the remainder of the Eucalypts, and a most heterogeneous and extensive collection they

are, variable in many ways. As a matter of fact the anthers refuse to be rigidly marshalled into sections. They sometimes display such variation of divergence of cell, size, and mode of dehiscence that classification on the anthers alone becomes a matter of difficulty. In the old collections the difficulty is enhanced through the partiality of insects for these organs. Nevertheless examination of the anthers is always carried out by me, and it is a most useful character.

Pollen-grains—Mueller (*Eucalyptographia*, under *E. erythrocorys*), has shown that the size of pollen-grains varies in different species, but we require very many more measurements than are available to be in a position to place any interpretation upon the results. The shape of the pollen-grains also varies, but we have few data on the subject.

Calyx—The calyx, "cupula" of De Candolle and other botanists, the "hypanthium" of Schauer, is no longer used for classification purposes, having been proved to be so utterly variable. De Candolle (and his translator G. Don) offered a classification of the Eucalypts consisting of opposite or alternate leaves combined with a comparison of the size of operculum with the cupula.

Fruit—While many botanists have more or less used the fruit as a diagnostic character in Eucalyptus, and it is undoubtedly the best character we have, it is due to Professor Tate to say that (*op. cit.*) he was the first to submit a scheme for classification of the genus based on the fruits alone. He deals with (*a*) shape; (*b*) external sculpture and ornament; (*c*) capsular-teeth; (*d*) capsule-cells; (*e*) fertile seeds. But examination of Professor Tate's scheme shows (through no fault of his) how very imperfect and full of exceptions it is. Taking item by item we find the shape in each species to vary within wide limits. Per-

sonally I very largely use the fruit (unripe fruits may be very misleading), for diagnostic purposes, but in many cases it must be carefully used for it displays an enormous amount of variation. This much is proved, and I go further and say that some fruits only appear to have an approximately constant shape because we have so much to learn in regard to the range of the species and consequent possibilities of variation. Of course I at once admit the fact that some species are "stronger" than others. To sum up, for herbarium work the anthers and fruits are the best characters to go by; for the scientific forester, the bark and the timber, but all characters display a puzzling amount of variation.

II. Has variation in Eucalyptus now ceased?

Bentham (B. Fl. iii. 186—188) shows the variability of the various characters of the genus, and notes on variation are given to nearly all his groups and series.

At p. 186, he says:—

"It must be admitted, indeed that these groups, distinct as they may be in the typical species, pass very gradually into each other through intermediate forms, but I have endeavoured to supply cross-references to facilitate the determination of dried specimens in doubtful cases."

And again:—

. . . "but to the botanist who is unable to compare them in a living state, the due limitation and classification of their species presents almost insuperable obstacles. The extraordinary differences in the foliage of many species at different periods of their growth add much to the ordinary difficulties arising from the gradual transition of varieties, races, or species one into the other."

Mr. R. T. Baker however, holds a different opinion. For example:—

"This constancy is accounted for by the author on the geological age of this continent, for whilst other continents have undergone subsidences and upheavals, Australia has stood still or remained stationary, thus giving the plants enormous periods of time for differentiation, so that the "missing links" naturally are wanting."[1]

And again:—

"In this paper the author endeavours to show that much of the hitherto supposed variability of specific characters of our Eucalyptus trees is the result of various artificial classifications applied to the species in the past, whereas, if classified on what appears to be a natural basis, the species possess very little, if any, variability, and retain in a marked degree individual character through their whole area of distribution. Each species is taken *seriatim* to prove a *want of variation* in its specific characters."[2] (The italics are mine).

Further:—

"By following a natural classification, that is, one founded on a long and intimate acquaintance with the trees in nature, their habits and places of growth, the form and qualities of their seed, the manner of their elevation, increase and reproduction, the peculiarities of their radication, their interior substances, the infinitely varied formation of their vascular system (by which the plant is not only enabled to circulate the juices necessary to its support), the peculiar qualities of seeds, salts, gums, resins, oils by which they are distinguished, and all other constituents on which their natural combination so ultimately depends, almost all traces of variability disappear, and the above anomaly or difficulty in timber identification would be obviated."[3]

Messrs. Baker and Smith[4] further state:—

"We are now able to demonstrate most fully that of all the numerous peculiarities of the Eucalypts not one is of greater value

[1] "On the constancy of the specific characters of the genus Eucalyptus." Proc. Aus. Assoc. for Adv. of Sci., Melbourne Meeting, 1900.

[2] R. T. Baker, *op. cit.* [3] *Op. cit.*

[4] This Journal, xxxv., 121.

in indicating differences in the several species or that is more conclusive in its results, than is the *practical constancy* of chemical constituents in identical species, a fact of the greatest scientific and economic importance."

By "identical species" it is not certain whether botanical or chemical species are referred to. And again:—

"That the constituents have been *fixed and constant* in the oils of the several Eucalypts for a very long period of time."

It is added that the venation of the leaves and their botanical characters "show also a *marked constancy*." All this comparative constancy is probably accounted for by the long period of time that must have elapsed before a particular species could have established itself as such over so extensive a range as we find species to-day.

"The chemical and botanical peculiarities must also have been *fixed* primarily, because *we do not find the differences in characters one might expect by environment.* Our researches seem to show that the species are only well marked varieties in which the distinctive characters *have become permanent.*"[1] (The italics are mine).

These statements are quite definitè. The authors state that the genus Eucalyptus has now become fixed.

By what authority can anyone venture to say that variation has ceased in the genus? I regret that such a statement has been made, as it seems to be specially unfortunate. In view of the evidence I have already adduced, I imagine most botanists will ågree that the genus is as variable as *Rubus*, *Rosa*, *Hieracium*, *Cinchona*, or *Salix*.

A friend humorously expressed the situation by saying, "There is so much variation that there is really but one species, and its name is *Eucalyptus australis*." The late Rev. Dr. Abbott made a somewhat similar utterance when,

[1] Baker and Smith, this Journal, xxxv., 122, 123.

speaking of the English language and of its marvellous flexibility, he declared that "Any part of speech may be used as any other part of speech."

My studies of this genus have shown me that variation exists in every species with which I am acquainted. Some species are undoubtedly "stronger" than others, but the more we collect and the more we observe, the more we find old barriers between old species break down. With some species one is inclined to say, "What character is constant! there is no safety unless one keeps the type in sight just as the mariner does the light of the light-house." To pursue the simile further I am sure that the only way to avoid botanical shipwreck is to stick to the type.

III. Some Studies in Variation.

We have now arrived at the point when it will be profitable to consider specific instances of difficulties of classification through variation. I would invite attention to a paper[1] I have recently written to illustrate this point. In summing up, I show that we have the following names for the Gum-topped Stringybarks of Tasmania (which extend into Victoria and Southern New South Wales), that is to say for practically the same tree:—

1. *E. Risdoni*, Hook. f. var. *elata*, Bentham.
2. *E. radiata*, Hook. f. (var. 4), non Sieber.
3. *E. obliqua*, L'herit.
4. *E. regnans*, F.v.M.
5. *E. amygdalina*, Labill.
6. *E. dives*, Schauer.
7. *E. haemastoma*, Sm.
8. *E. virgata*, Sieb. var. *altior*, Deane and Maiden.
9. *E. oreades*, R. T. Baker.
10. *E. Sieberiana*, F.v.M.
11. *E. delegatensis*, R. T. Baker.

[1] The Gum-topped Stringybarks of Tasmania; a study in variation.—Read before the *Roy. Soc., Tasmania*, 1902.

The Gum-topped Stringybark has therefore been duly named, and has been given ten synonyms in addition,—not hastily, but by men who have worked on the genus, and who have given reasons for their determinations. The great majority of the determinations can still be defended, and may be looked upon as indicating forms of the species referred to. Study of the Gum-topped Stringybarks presents one of the best instances of variation in the genus that I have met with, and affords a most instructive example of the necessity, in this protean genus, of endeavouring to ascertain what is the type, and of bearing it closely in mind.

Again, who will have the temerity to define the boundaries between the Stringybarks, *Eucalyptus eugenioides*, *capitellata* and *macrorrhyncha*, and between all of them and *E. pilularis?* I could give dozens of specific instances in which species run into each other, showing that we are striving after a wrong ideal when we endeavour to stereotype them.

IV. Mannas, Kinos, Oils, etc., are non-essential but accessory or adaptive characters and examination of them must be simply looked upon as aids to diagnosis.

Volatile oils (*e.g.*, of Eucalyptus) are what are termed accessory substances, that is to say, they are not essential to the plant. They probably have various functions, *e.g.*,[1]

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[1] This is of course following Tyndall, who showed that an envelope of aromatic air around a plant is less pervious to heat rays than is ordinary atmosphere.—Kearney, "Report on a botanical survey of the Dismal Swamp region."—(*Contrib. U.S. Nat. Herb.*, v., 6, p. 392), says, "How effective this may be is yet very doubtful, but it is not to be denied that such aromatic plants are much more abundant in dry soils and climates, where the water supply of the plant needs to be jealously guarded than where other conditions prevail." He quotes Pfeffer (*Pflanzenphys.* 2te Auflage, I., 501) who considers that this exhalation is "hardly of high importance" for protection against loss by water.

(1) to create a halo of vapour which checks transpiration, (2) to attract, by their odour insects necessary for fertilizing the plant, and (3) render the plant nauseous to some insects and animals which would otherwise prey upon it.

Such accessory characters cannot obviously be other than variable, yet Messrs. Baker and Smith[1] say "that the constituents have been fixed and constant . . . . "their botanical characters show a marked constancy" . . . "the chemical and botanical peculiarities must also have been fixed primarily."

The key to the oil question has less to do with the determination of species, but depends on examination of the minute morphology (anatomy) of the leaf.

V. Botanical Classification for purposes of Nomenclature of Genera, Species, and Varieties is based on morphological characters.

It is the object of botanists to construct a Natural System. Linnaeus in proposing his artificial system, which met the requirements of his day, still looked upon a truly natural system as the ideal of botanists. As time has rolled on we have steadily approached this ideal. Jussieu, DeCandolle, Bentham, Hooker, and others have made marked progress in perfecting the natural system, and Engler in his Pflanzenfamilien and now his Pflanzenreich, is, with the assistance of coadjutors, showing the latest progress in this direction. All these authorities base their systems on morphological characters, and it is of course their object to associate closely related forms.[2]

[1] This Journal, *loc. cit.*

[2] I do not lose sight of the fact for one moment that, in the discrimination of genera and species we should call to our assistance any characters that can be employed to that end. Prof. John M. Coulter in his Vice-Presidential Address, Section F. (Biology) *Amer. Assoc. Adv. Science*, 1891, p. 300, eloquently pleads for a philosophical conception of a species in

Mr. Baker however, contends that, at all events as regards the genus Eucalyptus, this method of classification is wrong. Following are some of his statements.

"And all this is due to our having classified in the past our Eucalypts on what the author contends is an artificial basis, namely, morphological characters."[1]

And again:—

"In many instances it is impossible to classify Eucalypts on the shape of fruits, anthers, buds, and leaves, and in this connection is mentioned the case of *E. bicolor* and *E. pendula*, of A. Cunningham. It has been customary in recent times to synonymise these species under the name of *E. largiflorens*, F.v.M. Now Cunningham, who was a field botanist and who was familiar with these trees, named the bastard box of Cabramatta *E. bicolor*, a tree with a *dark box bark* on the stem, and with clear *white* limbs, and having a lightish brown coloured timber, whilst the "Coolabah" of the interior he named *E. pendula*, from its drooping habit. This tree has a red coloured timber, and a bark extending to the ultimate branches. The oils of the two trees are quite distinct. The economic and systematic materials of *E. pendula* having been obtained from many parts of the Colony, and show the usual constancy of specific characters which the author has found to hold in almost all other Eucalyptus species. This also applies to *E.*

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the following passage:—"The character of a species is an extremely composite affair, and it must stand or fall by the *sum total* of its peculiarities and not by a single one. A specific character in one group may be a generic character in a closely related one, or no character at all. Therefore, there is nothing that involves a broader grasp of facts, the use of an inspiration rather than a rule, than proper discrimination of species. I have a belief that the arbitrary, rule-of-three mind will never make a successful taxonomist; and that there is a sort of instinct for specific limitations which the possessor cannot communicate to another. This taking into account the total character of a plant, from *facies* to minute characters, will furnish the basis of future descriptive work. The more obstacles that can be put in the way of hasty determination the better."

[1] On the constancy of the specific characters of the Genus Eucalyptus. —Proc. Aust. Assoc. for Advt. Science, Melbourne, 1900, p. 229.

bicolor, and on these grounds it is contended that the two trees should be regarded as distinct species. The only resemblance is the venation of the lanceolate form of leaf. If placed under *E. largiflorens*, then there would be the anomaly of having under one species a tree with two kinds of timber, two kinds of oil, and a variation in leaves."[1]

This argument is, however based on wrong determinations. I have shown, on morphological grounds and reference to the actual types, (*Proc. Linn. Soc. N.S.W.*, 1902), that the *E. bicolor* referred to above is *E. Bosistoana*, F.v.M., and that the *E. pendula* referred to is really *E. bicolor*, A. Cunn., thus some of the deductions based on the assumption that his determinations are correct, fall to the ground.

Again Messrs. Baker and Smith have in this Journal added a new species to science (*Eucalyptus apiculata*, Baker and Smith), in the following words:—

"The oil obtained from a Mallee[2] known as *E stricta* was different from that obtained from the supposed *E. stricta* growing around Berrima and Mittagong, but it was not possible to separate them on any known botanical characters, *as no morphological differences could be detected*, but the fact remained that the oils were different and always so . . . thus we propose to make the Berrima form distinct, and give it specific rank under the name of *Eucalyptus apiculata*."[3]

Surely this cuts at the very foundations of systematic botany. If two plants are morphologically identical one may be substituted for the other.

The plants to which Mr. Baker refers have been known to botanists for many years and they have agreed with Mr. Baker that "no morphological differences can be detected" between *E. stricta*, Sieb., and *E. apiculata*, Baker and Smith. As Mr. Baker has stated that the two plants

[1] *Op. cit.* [2] It is not a true Mallee. [3] This Journal, xxxv., 121, 122.

yield different oils, botanists will (as I have already done) still further examine them to see if they possess morphological differences that are at present not obvious to our own eyes. When any differences are detected surely it will be then time enough for a new name to be proposed, for at present it is obviously impossible for the botanist, unless he subjects the plant to distillation, to say whether he has collected *E. stricta*, Sieb. or *E. apiculata*, Baker and Smith.

Messrs. Baker and Smith's statement that there is no morphological difference between the plants and yet the oils vary, may surely be interpreted as evidence in favour of the view that the oils in plants vary according to environment. It is a matter of common experience in Europe that the same plant, cultivated in different soils and situations, yields oils varying much in quantity and character. Acting on that experience cultivators only attempt to grow oils of certain grades in special soils and situations. I think I have shown, beyond doubt, that all other characters of Eucalyptus vary. There seems to be no evidence why the oil should present a remarkable exception to the general rule.

It seems strange to me that with evidence (as I contend), simply inexhaustible, of variation in Eucalyptus, both as regards spontaneous and cultivated plants, where it is sometimes necessary (I believe) to name a plant with the qualifying note that another botanist may have good grounds for placing it in an allied species, this doctrine of variation apparently does not command universal acceptance. It seems to me that the "non-variation" theory runs counter to some of the most generally accepted sets of practical observations on which the doctrine of evolution of species is based, and there is just a little danger of what Darwin terms "arguing in a circle" in presenting the observations that are interpreted to destroy the dogma which many of us look upon as built on unassailable facts.

THE BOOGALDI, BARRATTA Nos. 2 AND 3, GILGOIN Nos. 1 AND 2, AND ELI ELWAH OR HAY METEORITES, NEW SOUTH WALES.

By A. LIVERSIDGE, LL.D, F.R.S., Hon. F.R.S. Edin., Professor of Chemistry, University of Sydney.

[With Plates III. - XV.]

[Read before the Royal Society of N. S. Wales, November 5, 1902.]

THE BOOGALDI METEORITE.

THIS meteorite was exhibited and described by Mr. R. T. Baker, F.L.S., at a meeting of this Society in June 1900.[1] Mr. Baker states that the meteorite was found by Mr. Gould in January 1900 lying on the ground at a place about two miles from Boogaldi Post Office and fifteen miles north west from Coonabarabran which is 267 miles north west from Sydney. In driving near the spot Mr. Gould, noticing that the ground on a hard ridge had been torn up, followed the furrow and found the meteorite, with its larger end slightly embedded in the earth. Mr. Wilcox, the local postmaster, afterwards accompanied Mr. Gould and examined the spot, and they came to the conclusion that the meteorite had travelled from the north west and had reached the ground at a very low angle. The meteorite was secured by Mr. Baker for the Technological Museum, and submitted by him to me for a fuller examination and analysis.

Description.—This meteorite is an exceedingly interesting one and somewhat resembles the Bingera meteorite[2]

[1] Journ. Roy. Soc. N.S.W,, 1900, p. 81. A. Liversidge, *ibid.*, p. 83. The publication of the account of the Boogaldi meteorite has been delayed pending the preparation of sections and illustrations.

[2] Journ. Roy. Soc., 1882, p. 308.

in form, but is much larger. Like the Bingera one it is a siderite or metallic meteorite and is also somewhat pear-shaped; it is a little over five inches long by about three inches broad at the widest part, and it weighed before cutting 2057·5 grammes. Its sp. gr. at 14° C. was found to be 7·85. It was covered with the usual closely adherent skin of fused oxides, except in one place where the skin had been detached, probably when the meteorite first came in contact with the ground—the Bingera meteorite also showed a similar bare spot—the exposed metal had a bright lustrous appearance like nickel iron. In places thin crack-like markings are present in the skin; some of these are evidently closely related to the crystalline structure of the mass within, as they are straight as if ruled and meet at definite angles. A few pits are noticeable upon the surface; these are probably due to the former presence of granules of troilite (FeS), inasmuch as some granules of this mineral were found when making the sections of the interior; fissures in the skin are seen starting from these pits, but these are irregular cracks quite distinct from the sharper and straight lines, meeting at definite angles, previously referred to. In addition to the larger and deeper pits which pass into the substance, there are in places numerous small ones due to the escape of gas bubbles from the fused skin of the meteorite; these small pits resemble the gas bubbles met with in slags and fused iron scale, see *Plates 3, 4, 5* and *6*.

There is, in addition, a very remarkable structure in the skin; shown most clearly at the two ends of the meteorite, which I have not observed in any other meteorite. At the thick end of the meteorite the fused oxides forming the skin have been thrown into well defined concentric waves with transverse furrows running in the direction of the thinner end of the meteorite, the waves and furrows gradu-

ally fade away in this direction. (See *Plates* 5 and 6, figs. 3 and 4). I think that these waves and furrows clearly show that the meteorite travelled through the earth's atmosphere with the thick end in front, the waves of fused oxides being thrown up by the resistance of the air, just as waves are formed in water or sand by the wind, or at the bows of a boat. That the meteorite did travel with the thick end first is confirmed by the fact that at the thin end there are longitudinal ridges and furrows in the fused skin which clearly show where the excess of fused oxides dripped off in the passage of the meteorite through the air, see *Plate* 6, fig. 5, and also the thin end of fig. 1, *Plate* 3. The luminous streak usually seen behind a moving meteorite is, if not wholly, certainly in part, due to such fused and incandescent matter left in its trail. Hence the waves and other markings in the skin not only show that the meteorite travelled with the thick end first, (this view is supported by the position in which the meteorite was found), but also its position while in flight, *i.e.*; with the curved point of the thin end downwards as represented in *Plate* 4, fig. 2; for the fused oxides forming the skin are thickest on the lower side of the pointed end; and as I have also pointed out, there are the remains of the drops where the melted material dripped off. The thick end also has the longest and thickest streaks of fused skin on this side, and that the fused oxides dripped off from this part also is quite evident.

Sections.—These were made by means of a steam hacksaw in the University Engineering Laboratory. The sections were made with great care so as to expose as large a surface as possible and yet leave all the drip markings absolutely untouched. (See *Plates* 5 and 6, figs. 3, 4 and 5). The sections were polished and some were etched with copper sulphate, but the one figured on *Plate* 7, was done with

bromine as it was found to yield the best surfaces. The crystalline structure is well defined (octohedral) with a damascene-like lustre, and it is noticeable that the groups of crystals pass obliquely across from side to side and from end to end of the meteorite. One or two small specks of troilite are to be seen, and at the thick end are two well marked cracks which pass out right through to the crust and are connected with the pit at the thick end (See *Plate* 4, fig. 2). The crystalline structure is distinct from that of any of the other Australian meteorites which have come under my notice. The absence of deep pits and thumb-like markings on the surfaces of this and the Bingera meteorite may be due to the absence of large troilite enclosures.

Chemical Composition.—A qualitative analysis showed the presence of iron, nickel, cobalt, manganese,? chromium, copper, tin,? arsenic, gold and platinum (or metals belonging to the platinum group), also carbon, phosphorus and sulphur.

The gold and platinum were first found in the residue left after acting upon the meteorite with cold hydrochloric acid, to which sulphurous acid had been added to render it free from chlorine. The residue was then ground with water in an agate mortar and the lighter materials washed out; any magnetic particles were next removed by a magnetised needle; some bronze coloured metallic looking feebly magnetic and fairly malleable particles were usually left, soluble in nitric acid; these contained copper, chromium and iron, and require further examination. The particles of what appeared to be gold and platinum were then picked out on the point of a needle and examined under the microscope, when warmed with nitric acid on the microscope slide; they were found to be insoluble; to make doubly sure, the evaporation with nitric acid was repeated.

Yellow and white metallic particles, apparently gold and one of the platinum metals, were also obtained in the

precipitate thrown down from the hydrochloric acid solution of the meteorite by hydrogen sulphide, although these metals in the free condition are usually regarded as being insoluble in hydrochloric acid free from chlorine; they may, however, be present in the meteorite in the form of compounds or alloys soluble in hydrochloric acid. The gold and platinum-like metals were separated from the brown precipitate thrown down by hydrogen sulphide, by igniting it (so as to drive off the sulphur) and then repeatedly grinding the residue with water in an agate mortar as above described, the oxides of the lighter metals were gradually washed off and the free metals obtained in the form of yellow and white spangles, insoluble in hot nitric acid and therefore presumably gold and one or more of the platinum metals; the quantities obtained were too small to weigh; although the process of grinding in an agate mortar is an exceedingly delicate test, far more so than the wet tests, yet some of the metallic particles are probably lost, since it is difficult to prevent the very thin spangles of the precious metals from floating off during the process of washing. The results are not those of a single experiment as is shown by the following:—

Experiments—(*a*) 20 gms. of the sawdust from the meteorite were dissolved in hydrochloric acid, the insoluble residue on grinding left a few small specks of both yellow and white metals insoluble in nitric acid, and the hydrogen sulphide precipitate from the solution, after ignition, yielded specks of a white metal insoluble in nitric acid; therefore presumably both gold and platinum are present.

(*b*) 20 gms. of sawdust treated as above, also yielded what appeared to be gold and platinum in the insoluble residue, but none was found in the SH_2 precipitate.

(*c*) 20 gms of sawdust yielded a few specks of a yellow metal which were insoluble in nitric acid, therefore presumably gold.

(*d*) 20 gms of sawdust yielded a trace of platinum in the residue from HCl and in the precipitate from SH_2 but no gold.

(*e*) 8 gms of sawdust expressly obtained from another part of the meteorite, with a new saw and a different machine, yielded two bronze coloured metallic specks soluble in nitric acid and some yellow metallic specks insoluble in nitric acid and therefore presumably gold.

(*f*) A portion of a slice of the meteorite weighing 7·8 gms yielded both gold and platinum in the residue insoluble in hydrochloric acid.

[The sawdust affords a much better average sample than a fragment or slice of the meteorite, inasmuch as it represents the composition of a slice right through the mass of the meteorite; the loss in weight of the hard steel saw is extremely small and the percentage results are practically unaffected by the steel worn from the saw; thus in cutting slices from the Narraburra siderite in which 478 gms. of sawdust were obtained, the saws only lost ·94 gm., *i.e.*, the sawdust only contained ·2% of steel from the saws].

(*g*) The bromine which had been used for etching the meteorite was also tested for gold and platinum. This, of course, yielded a sample giving the average composition across the section, and consisted mainly of iron, nickel, and cobalt as bromides; it was evaporated to dryness and heated, some of the ferric bromide volatilized and part was converted into iron sesquioxide—this residue was extracted with chlorine water for 24 hours, decanted and evaporated down. On grinding portions of the residue in an agate mortar, one yielded a speck of yellow metal and three others yielded specks of a platinum-like metal. Both metals were insoluble in nitric acid.

The amount of gold and platinum left was too small to admit of the application of the usual wet tests, but some

of the yellow metal was dissolved in aqua regia and the solution taken up on a scrap of filter paper and exposed to the sunlight; after a day or so the paper acquired the usual pinkish tinge yielded by very dilute solutions of gold chloride.

Every precaution that I could think of was taken to avoid the access of gold and platinum in these experiments; the agate mortar and pestle were tested by grinding them for long periods with materials free from gold and platinum, and different agate mortars and pestles were used including a perfectly new one, no trace of gold, platinum or other metal was obtained from any of them. And nothing containing either gold or platinum had ever been in contact with the saws, which were new, and as far as I can ascertain nothing containing either gold or the platinum metals had been worked in the building in which the cutting and plaining of the meteorite had been carried out. Everything was scrupulously cleaned up after each cutting.

The results of several experiments with *filings* from this meteorite which yielded somewhat larger quantities of gold and platinum are omitted, because I am not absolutely sure that a new file had been used, and the vice had been used for holding gold and platinum nuggets.

The first few white metallic spangles obtained from some of the filings were insoluble in a mixture of nitric and hydrochloric acids, even when warmed and evaporated to dryness, neither did they appear to diminish in size or to change in any way, (the action of the acids being watched under the microscope with a one inch lens); they appeared therefore to be particles of iridium or of iridium metals, but as they were obtained from the filings, I do not now regard the presence of iridium metals as absolutely proved, although in a preliminary notice of this meteorite I had regarded them as present.[1] The white metallic spangles

[1] Journ. Roy. Soc., N. S. Wales, 1902, p. 282.

insoluble in nitric acid, yielded by the sawdust and by sections of the meteorite itself were soluble in aqua regia.

I have not come across any previous statements as to the presence of gold in meteorites, but the platinum metals have been met with before. Palladium is recorded as occurring in a meteorite by G. Trottarelli.[1]

A paper on the occurrence of platinum and iridium in meteoric iron, was read before the Rochester Academy of Science on Oct. 11, 1898, by John M. Davison,[2] in which he gives the results of some experiments upon meteóric irons. He found on dissolving the Coahuila and Toluca irons in hydrochloric acid that "they left a fine black sediment consisting mainly of minute tetragonal prisms of rhabdite, minute black irregular crystals which may also be rhabdite, carbon and a little stony matter. 500 grams of Coahuila iron left 9·386 grams of residue. Diamonds were not found in these residues."

"From this sediment platinum was obtained in each analysis, 606 grams of Coahuila iron yielded ·014 gram of metallic platinum and ·0015 gram of a black powder, insoluble in nitrohydrochloric acid, but after fusion with zinc dissolving in that acid and giving with ammonium chloride a dark red crystalline precipitate, which is probably ammonium iridi-chloride."

"From 464 grams of Toluca iron a few crystals of potassium platinichloride were obtained. These show a reddish colour and probably contain iridium. Platinum vessels were not used, the reagents were tested and all precautions taken against accidental contamination."

Mr. J. C. H. Mingaye, F.C.S., Chemist to the Department of Mines, New South Wales, records the presence of

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[1] Journ. Chem. Soc., Abstracts, 1891, p. 533.

[2] American Journal of Science, Jan. 1899, p. 4.

platinum in a native iron sent for analysis.[1] Mr. Mingaye informs me that in testing for gold and silver the residue insoluble in hydrochloric acid, was scorified with lead, free from gold and silver, and cupelled, when one of the platinum metals was found to be present; the metal was alloyed with about 20 times its weight of silver and parted with dilute nitric acid, after removal of the silver, the light yellow solution gave the usual reactions for platinum; with stannous chloride and potassium iodide as a colour test he estimated the amount of platinum present as being under 2 dwt. per ton.

Partial Analysis of the Boogaldi Meteorite.

Insoluble in HCl	·0400
Iron	91·1350
Nickel	8·0517
Cobalt	·4833
Copper	·2801
Arsenic	traces
Phosphorus	undetermined
Carbon	,,
Sulphur	,,
Chromium	,,
Gold	,,
Platinum	,,
	99·9901

The nickel and cobalt were determined electrolytically after the removal of the iron by litharge; to make sure that the arsenic had not been derived from the hydrogen sulphide used in precipitating the metals of the copper group, the gas was first purified, tested, and proved to be free from arsenic. The amounts of several elements present have yet to be determined and this meteorite has still to be examined for diamonds, occluded gases and spectroscopically.

[1] Annual Report of the Department of Mines, 1898, p. 21.

Barratta Meteorites, No. 2.

Mr. Russell, B.A., C.M.G., F.R.S., Government Astronomer, states that on May 23rd, 1889, he received from Mr. W. Kilpatrick of Cornalla Station, two meteorites which he had found on Barratta Station, 34 miles north of Deniliquin and near the place where the large Barratta meteorite was found about the year 1860.[1] To distinguish these meteorites from the one previously described, they will be referred to as Barratta meteorites No. 2 and No. 3.

Mr. Russell says[2] that one of the new meteorites (Barratta No. 2) is remarkably like the large one he has had for so many years. He describes it as somewhat like the former in colour both internally and externally, but it is not so deeply fused on the surface. Its specific gravity is 3·706, that of the old one being 3·387, and the weight 31½ lbs., the other (Barratta No. 3) weighed 48 lbs. and its specific gravity is 3·429; these data were determined by Mr. Russell by weighing the whole mass of each meteorite.

The three Barratta meteorites do not seem to have weathered to any extent and are intact except for some pieces which have been broken off by a hammer. All three show large surfaces free from fused skin as if they had been fractured after their flight had been either wholly or in part arrested.

Amongst the principal constituents easily recognised in the photograph are chondri of enstatite, much fissured, olivine, and particles of the nickel iron alloy. The metallic portion of Barratta No. 2 in 34·5 grammes was found to be 6·13%; the amount varies in different parts as the metallic particles are clearly seen to be unequally distributed.

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[1] A. Liversidge—Journ. Roy, Soc., N.S.W., 1872, p. 97; *Ibid.*, for 1880, p. 308, and 1883, p. 31. A. Brezina—Ann. K. K. Nat. Hist. Hofmuseum, Wien, 1895.

[2] Journ. Roy. Soc. N.S.W., 1889, p. 46.

The composition, after the removal of the metallic part by the magnet is given below; this method also removes some non-metallic matter, hence neither this nor the non-magnetic residue is quite normal in composition. It would probably have been better to dissolve the metallic portion by means of mercuric and ammonium chlorides, but the magnet process takes less time.

Non-metallic part—mean of two analyses.

Silica	41·673
Ferrous oxide	15·656
Ferric oxide	10·103
Alumina...	1·163
Manganese	traces
Nickel	·481
Cobalt	none
Lime	2·708
Magnesia	25·819
Soda (Na_2O)	·613
Potash (K_2O)	·087
Sulphur	2·061
Phosphorus	·067
	100·431
Less oxygen equivalent to sulphur and phosphorus	1·164
	99·267

The Metallic portion was found to contain:

Insoluble in HCl	1·855
Iron, metallic	81·108
Nickel	8·527
Cobalt	·121
Manganese	none

The sulphur, phosphorus and other constituents were not determined.

The metallic portion was fused with caustic potash to remove entangled silicates etc., but as the fusion with

alkali removes phosphorus, the results are only of value for the proportions of iron, nickel, and cobalt.

Plate 8 is from a photograph of Barratta No. 2.

Plate 10, fig. 9, shows the fractured surface of the meteorite Baratta No. 2, the light coloured oval and round spots are enstatite chondri and some of the bright specks are metallic. The metallic portions are shown better in the polished surface of the meteorite, see fig. 10 on the same plate, in the form of light coloured irregular markings, some are curved and a few are circular and are, apparently sections of investing coats of metallic matter, if the non-metallic nuclei could be removed we should apparently have hollow spherules of the nickel-iron alloy.

Plate 11, fig. 11, is a photograph of a section enlarged 12 diameters, of Barratta No. 2, which shows the fissured structure of the enstatite chondri, the opaque magma, and some of the metallic grains.

Barratta Meteorite No. 3.

Barratta meteorite No. 3 has not been analysed; it evidently belongs to the same original mass as Nos. 1 and 2.

Plate 9 represents Barratta No. 3.

Plate 11, fig. 12, shows portions of two of the enstatite chondri (enlarged 16 diameters) between them are to be seen thin pieces of the metallic alloy, the two lower ones roughly triangular in outline—the striæ on them are due to the polishing material.

Gilgoin Meteorite, No. 1.

This meteorite was given to Mr. Russell, C.M.G., F.R.S., by Mr. J. A. Yeomans of Gilgoin Station, where it was found in 1889. Gilgoin is 40 miles E.S.E. of Brewarrina, which is 516 miles N.W. of Sydney and 75 miles E. from Bourke, the latter town is 503 miles from Sydney and in

Lat. 30° 3′ S., Long. 146° 56′ E. Mr. Russell states[1] that its weight is 67½ lbs., and that it has a sp. gr. of 3·857. It is quite evident that at one time it was much larger as it is much weathered and cracked; in spite of every care large pieces have fallen off since it has been in Mr. Russell's possession.

The meteorite contains a considerable amount of metallic matter, 34 grammes yielded 14·7% of the nickel-iron alloy, hence it was troublesome to prepare the slides for the microphotograph as the metallic particles tend to tear out, and as might be expected it strongly attracts a magnetic needle. Like the Barratta meteorites the structure is chondritic. (See *Plate 12*, fig. 13.)

Ten grammes of this meteorite extracted with a magnet and then reground and washed in an agate mortar yielded two specks of a yellow metal, the smaller speck was insoluble in nitric acid with which it was twice evaporated down to dryness and therefore presumably gold. The somewhat larger and paler speck was slowly acted upon by nitric acid and left a black residue which may have been finely divided gold, but it did not acquire a metallic lustre when burnished. Afterwards 32 grammes were treated in the same way, some yellow metallic particles were obtained, but these dissolved in nitric acid. None of the others, viz. Barrattas 1, 2 and 3, Gilgoin No. 2, nor the Hay meteorite yielded gold.

Thirty-four grammes of the Gilgoin meteorite No. 1 yielded 7·3 grammes of magnetic matter and this after fusion with potash, left 5 grammes of metallic matter or 14·7% on the original 34 gms. As already stated this is not a satisfactory method, as the nickel-iron alloy (Schreibersite) loses phosphorus and the magnetic matter entangles

[1] Journ. Roy. Soc., N.S.W., 1889, p. 47.

with it some of the non-magnetic matter, hence the residue left by the magnet is altered in composition.

Magnetic portion.

Insoluble in HCl.	1·5074
Iron, metallic...	82·4551
Nickel ,, ... } Cobalt ,, ... }	8·3451
Sulphur	trace
Phosphorus	none
Oxygen and undetermined	7·6924
	100·0000

Non-magnetic portion.

Dried at 105° = ·349% of moisture.

Silica	42·690
Ferrous oxide...	12·665
Ferric oxide	6·698
Alumina	4·980
Nickel	·280
Cobalt	none
Manganese	traces
Lime	17·530
Magnesia	12·661
Soda (Na_2O)	·744
Potash (K_2O)	·104
Sulphur	2·535
Chlorine	none
Phosphorus	·135
	101·022
Less oxygen equivalent to sulphur and phosphorus	1·267
	99·755

GILGOIN METEORITE, NO. 2.

This meteorite was also forwarded to Mr. H. C. Russell, by Mr. Yeomans of Gilgoin Station. Mr. Yeomans in

writing to Mr. Russell on February 8th, 1893, states that the meteorite had been recently found about two miles south of the one (Gilgoin meteorite No. 1) he had previously sent Mr. Russell. Both were found on an alluvial plain free from rocks or stones. Mr. Russell considered it probable that as they were found so close together and are so similar in appearance and specific gravity that they originally formed parts of one meteorite, both travelled through the atmosphere a sufficient distance, after splitting up, to acquire the usual fused skin, although this is not so glossy as in some meteorites.

Mr. Russell states[1] that like the previous one this meteorite was also much weathered and cracked, some pieces have fallen off and many parts of the surface are ready to crumble away. The total weight of all the parts amounted to 74 ℔s. 4 ozs., and the specific gravity to 3·757. The main mass is roughly doubly convex, 14 to 15 inches in length and about 7 inches through at the thickest part. A freshly fractured surface is dark grey in colour and shows numerous bright white metallic particles. Its general appearance is represented in *Plate 14*. The microphotograph (*Plate 12*, fig. 13) shows the light coloured fissured enstatite and the metallic particles (grey) in an opaque magma.

The second Gilgoin meteorite has not yet been analysed. Although the fractured surfaces and micro-sections of the Gilgoin meteorites somewhat resemble those of the Barratta meteorites they appear to be too far apart in composition to have been portions of the same fall; the differences in the places and the dates at which they were discovered are not of much importance.

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[1] Roy. Soc. N.S.W., 1893, p. 361.

ELI ELWAH OR HAY METEORITE.

This meteorite was exhibited at a meeting of the Royal Society of N.S.W., on November 7th, 1888, by Mr. H. C. Russell, C.M.G., F.R.S., Government Astronomer,[2] who states that it had been found on Mr. J. Russell's Station Eli Elwah some 15 miles west from Hay, N.S.W., 454 miles south-west from Sydney; it was taken to the station by one of the men, who said that he saw it fall; but it had apparently been lying exposed for a considerable time, oxidation was going on very rapidly and it was probable that the stone would not last very long.

The fragment of this meteorite, given to me for examination and analysis by Mr. Russell, C.M.G., F.R.S., had a weathered and rusty look, but the interior is tenacious and hard enough to scratch glass; I understand however that the main mass of the meteorite originally $35\frac{1}{2}$ lbs. in weight is rapidly disintegrating (*Plate 15*). Mr. Russell found the specific gravity of the whole mass to be 3·537.

Externally the fragment looks like a piece of dark brown hæmatite with a blistered somewhat shiny surface. The rusty appearance of a freshly fractured surface is due to the dark brown colour of the material of the meteorite and to the presence of a yellow-brown mineral, probably olivine. Scattered through the mass are a few small cavities (rather unusual in meteorites), not exceeding 1 mm. in diameter. The meteorite gives a dark grey almost black streak on porcelain.

(*a*.) *Moisture*, lost at 110° to 115° = ·543%.

(*b*.) *Portion soluble in water*, = ·474%.

As it was thought that the meteorite from its weathered appearance might contain soluble salts a portion of the powdered material (3·0 grammes) was extracted with

[2] Journ. Roy. Soc., N.S.W., p. 341.

distilled water. The percentage of soluble matter was only ·477, and this consisted mainly of magnesium sulphate a little chlorine, lime and alumina were also present. The magnesium sulphate was probably due to the action of the sulphuric acid formed by the oxidation of the iron sulphide present.

(c.) *Portion insoluble in water, soluble in hydrochloric acid* = 43·624%.

Silica	
Ferrous oxide	16·885
Ferric oxide	6·441
Alumina...	·745
Nickel	1·000
Cobalt	none
Manganese	...
Lime	traces
Magnesia	16·678
Soda (Na_2O)	·727
Potash (K_2O)	·108
Sulphur	2·276
Phosphorus	·099
	44·959
Less oxygen equivalent to sulphur	1·335
	43·624

(d.) If the magnesia MgO in this be regarded as in the form of olivine, the amount of olivine (2 MgO, SiO_2) present will be 29·2%

(e.) *Portion insoluble in hydrochloric acid* = 55·072%.

Silica	39·075
Ferric oxide	2·643
Alumina...	2·096
Lime	1·589
Magnesia	8·649
Undetermined, alkalis etc.	1·020
	55·072

Next a portion of the meteorite was analysed without previous treatment with hydrochloric acid, so that the following results give the composition of the meteorite as a whole. Dried at 110°, loss = ·543%.

Silica	39·470
Copper	none
Tin	none
Alumina...	2·870
Iron sesquioxide	9·176
Iron monoxide	17·056
Nickel	1·010
Cobalt	none
Manganese	traces
Lime	1·605
Magnesia	25·583
Soda (Na_2O)	·735
Potash (K_2O)	·109
Chlorine...	trace
Sulphur	2·299
Phosphorus	·100
	100·013
Less oxygen = to sulphur and phosphorus ...	1·349
	98·664

Chromium, vanadium, etc., were specially sought for, but not found. 15·5 gms. crushed in a diamond mortar and ground in an agate mortar yielded 3 or 4 specks of a yellow non-magnetic metal soluble in nitric acid and therefore not gold.

The above amount of sulphur if assumed to be in combination as FeS, would represent 6·2% of troilite and the ·109% of phosphorus would represent 1·6% of Schreibersite $(FeNi)_4P$; if the whole of the nickel be also assumed to be present as $(FeNi)_4P$, it would represent 2·1% of Schreibersite. The nickel and cobalt were determined by electrolysis

after the removal of the iron by litharge; the cobalt was determined by the potassium nitrite process.

It was found very difficult to prepare a sufficiently thin section of this meteorite for the preparation of the microphotograph (See *Plate 12*, fig. 14) on account of its opacity and the tendency for the nickel-iron alloy to tear out during the grinding. The irradiation in the photograph is due to light getting through the apertures thus left; the white spots without structure indicate these holes. The amount of nickel-iron alloy present and its composition have yet to be determined.

Note.—The microscopic examination of the foregoing meteorites is not yet completed.

AN IMPORTANT GEOLOGICAL FAULT AT KURRAJONG HEIGHTS, N. S. WALES.

By Prof. T. W. EDGWORTH DAVID, B.A., F.G.S., F.R.S.

[With Plates XVI., XVII.]

[*Read before the Royal Society of N. S. Wales, December 3, 1902.*]

THE fault described in this paper is intimately related to the structural feature, a monoclinal fold, which forms the eastern escarpment of the Blue Mountains. As far as I am aware, the first reference to this from a scientific point of view is that by Darwin.[1]

Darwin was of opinion that the eastern escarpment of the Blue Mountains, " where it abruptly terminates over

[1] Geological Observations on the Volcanic Islands and parts of South America visited during the voyage of H.M.S. "Beagle," Second Edition, pp. 146 - 154, and specially pp. 149 - 150.

the Nepean," marked the original termination of a great bank of sediment, like those "within the West Indian Archipelago, which terminate in submarine slopes inclined at angles of between thirty and forty degrees." Later observers, however, favoured by better sections than those to which Darwin had access, have shown that this escarpment was not an original feature, but that it has been superinduced upon the strata, long subsequent to the time of their deposition, by earth-movement. Mr. J. E. Carne, F.G.S., has drawn my attention to the following reference to the monocline by the late Rev. W. B. Clarke:—"Along the Nepean, where the escarpment of the Blue Mountains forms the side of a great fault, the Wianamatta beds abut against the Hawkesbury rocks, or recline at a high angle on the slopes, proving there a distinct difference in time of deposit."[1]

The next reference noted by me is that by the Rev. J. E. Tenison-Woods.[2] He states, (*op. cit.*, p. 55) "There are, however, at the first Zig-zag very many signs of a downcast or fault. There the beds are for a very short distance highly inclined against the range, having the appearance of an immense landslip from the failure or subsidence of the ground. The rock which is inclined appears to be bent down from the main mass which is quite horizontal." In discussing Mr. Tenison-Woods' paper, Mr. C. S. Wilkinson said (*op. cit.* p. 93), "It has always been the opinion of geologists that there has been a subsidence of the area between the sea and the base of the ranges near the Nepean, as stated by Mr. Tenison-Woods."

Mr. C. S. Wilkinson, the late Government Geologist of N. S. Wales, also referred to this structure.[3] He says, "The

[1] Catalogue Nat. and Indust. Products, N. S. Wales, 1871, p. 520.
[2] "The Hawkesbury Sandstone," by the Rev. J. E. Tenison-Woods, F.G.S., F.L.S.—Journ. Roy. Soc. N. S. Wales, Vol. XVI., read May 20th, 1882, pp. 53-116.
[3] Mineral Products of N. S. Wales, 1882, p. 52.

abrupt eastern margin of the Blue Mountains, up which the Great Western Railway Zig-zag ascends at Lapstone Hill, near Emu Plains, marks the line of a similar, though not such an extensive fault, by which all the country between it and the coast was thrown down to its present level—the depression being so great that the ocean water flowed into the old river valleys, one of which forms the beautiful harbour of Port Jackson." A later brief reference is that made by Dr. J. E. Taylor,[1] in which he speaks of "the great Nepean fault."

In my Presidential Address to this Society in 1896,[2] I stated as the result of my observations in the field that the eastern escarpment of the Blue Mountains above the Nepean, from Lapstone Hill to the Kurrajong, was due to a monoclinal fold rather than to a fault, (*op. cit.* 63, and diagram 2, of plate II.)[3] On the same diagram it is shown that while the monocline depresses the Triassic Strata fully 400 feet in an easterly direction, there is also present a small fold in the strata about one mile west of the monocline, and passing through Glenbrook Railway Station. This small fold faces the west and displaces the strata in that direction to the extent of about 100 feet. It is possible that this western fold is accompanied by shearing, and it is almost certain that it is a structural feature which is identical with the Kurrajong fault.

There are thus at Glenbrook two geotectonic structures of importance (1) the eastern monocline of Lapstone Hill,

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[1] Our Island Continent—a Naturalist's Holiday in Australia, by Dr. J. E. Taylor, F.L.S., F.G.S., London 1886, pp. 249 - 250.

[2] Journ. Roy. Soc. N. S. Wales, Vol. XXX., 1896, pp. 33–41.

[3] I should like to take this opportunity of correcting an error made by me in drawing the Section, diagram 1 of Plate II., *op. cit.* The "Penrith Bore" is there shown as having been started at the top of the Hawkesbury Sandstone. The bore is in reality situated at the bottom of a deeply eroded gorge in the Hawkesbury Sandstone, forming the present channel of the Nepean River. The top of the bore is actually about 200 feet below the original top of the Hawkesbury Sandstone.

displacing the strata about 400 feet from the horizontal, and 350 feet from the inclined plane due to their normal easterly dip of about 100 feet per mile, and (2) a gentle westerly fold, one mile west of the eastern monocline and displacing the strata in a westerly direction 100 feet from the horizontal and about 175 feet from the inclined plane due to their normal easterly dip.

From Lapstone Hill the above two features strike very nearly due north to the Grose Valley, and it is evident from the surface features, though the country has not yet been geologically examined, that they reappear on the north side of that valley but in a position about a mile west of the general strike from Lapstone Hill. The cause of this horizontal displacement has not yet been ascertained (see *Plate 16*). It is certain at all events that at the Kurrajong Heights two structures similar to but on a larger scale than those at Lapstone Hill and Glenbrook make their appearance, at a distance of about 15 miles northerly from Glenbrook.

It is clear that the Kurrajong monocline is a continuation of the Lapstone Hill monocline, and as shown by *Plate 16*, there is a strong probability that the Kurrajong fault is a continuation and development of the Glenbrook fold.

The existence of the fault at the "Cut Rock," Kurrajong Heights was first suspected by me through viewing from Woodford the general surface configuration of the Blue Mountain Plateau. It was apparent that the bold line of the Kurrajong Heights which bounded one's view in an E.N.E. to N.E. direction marked a feature due to some cause other than mere erosion, and was therefore to be ascribed to folding or faulting.

With a view of testing this opinion by direct observation Mr. G. W. Card, Assoc. R.S.M., F.G.S., and I visited the Kurra-

jong Heights on November 19th last, and found conclusive evidence of the existence of a slight fold and strong fault at the "Cut Rock." Later on, December 12th — 15th, Mr. E. F. Pittman, Assoc. R.S.M., and I made a cursory examination of the country for over 12 miles westerly from the Kurrajong Heights as far as the top of Mount Tomah and northerly from the Kurrajong for over five miles to the "Mountain Lagoon." We ascertained as the result of this examination that the downthrow was not restricted to the immediate neighbourhood of the fault but that the whole strip of the Blue Mountains between Kurrajong Heights and Mount Tomah had subsided, the western edge of the 'senkungsfeld' being bounded at Mount Tomah by an easterly monocline and the eastern edge by a fault and slight western fold (See Section on *Plate 16*). Later, with a view to determine the throw of the fault more accurately it was decided to remeasure it, and Mr. G. H. Halligan, L.S., F.G.S., very kindly surveyed the fault with me with a chain and theodolite on January 1st, 1903. The results of these observations may now be given.

Details of Section from Richmond to Mount Tomah.— Only brief reference will be made here to the above, as they will be given fully in the Geological Survey Memoir, to appear later.

Richmond is situated on a plain of brick red sandy soil, about 60 feet above sea level. This deposit is of fluviatile or lacustrine origin. The highest modern floods in the Hawkesbury do not come nearer than within 10 to 12 feet (measured vertically) of its summit. It would be interesting to ascertain whether in the Richmond District, as at Maitland, this red soil deposit is underlaid by 'raised beaches' of estuarine origin. The red soil alluvial plain has been terraced by the Hawkesbury River, and the modern loamy alluvial plain has been deposited in the eroded hollows in the older alluvials.

The recent alluvials as shown on the section, *Plate 16*, are about a mile in width near the low level bridge over the Hawkesbury River at Richmond. On the left bank of the river near the bridge, the low and high level alluvials quickly give place westwards to the Wianamatta Shales, the uppermost member of the local Trias System. A mile further west the middle member of the system, the Hawkesbury Sandstone, is seen as an inlier (see section of *Plate 16*). From here for about four and a half miles further west the Wianamatta Shales reappear attaining a thickness of about 250 feet between the Trigonometrical Station called "Pound," and the point where the road to Grosevale leaves the Kurrajong road above Little Wheeny Creek. About one mile down the Grosevale road from where it leaves the Kurrajong, an ostracodan sandstone was found on the occasion of the visit by Mr. Card and myself. This is about three feet thick and will be described in the Geological Survey Memoir. At little Wheeny Creek, on the Kurrajong road there is another inlier of Hawkesbury Sandstone, capped further west by the Wianamatta Shales at the foot of the long hill ascending to the Kurrajong Heights.

For the first mile on the ascent a gentle easterly dip of 2° to 3° prevails. Then at a point about 360 yards W. 7° N. from the old school building at the junction of the road in portion 161 Parish of Kurrajong, the foot of the monocline is reached at a level of about 880 feet above the sea. The dip of the Wianamatta Shales at that spot is E. 12° S. at 20°. A little further up at the lower junction of the old and new Kurrajong roads the Wianamatta Shales thin to a thickness of only 20 feet to 50 feet, the Hawkesbury Sandstones making their appearance in all the gullies. The level at the preceding road junction is about 1,066 feet above the sea. At 200 yards further up the hill the dip lessens to 16°, and near Mr. Powell's house at the N.W.

corner of portion 182, Parish of Kurrajong, at the upper junction of the new and old roads, the dip is E. at 8°. At the 11 mile mark, at little over 300 yards on the Kurrajong side of the top of the ridge, the dip is from S.E. to E.S.E. at a low angle, perhaps about 6°.

The ridge forming the Kurrajong Heights is bounded on the west by a steep slope of from 10° up to 34° (see *Plate 17*). The Wianamatta Shales are truncated by erosion at the top of the ridge. On descending the slope the observer comes at once on massive Hawkesbury Sandstone which still maintains an easterly dip of about 6°. gradually lessening until within about four chains of the foot of the hill when they become flat. They then dip over to the west at angles which extend up to 10°, and then within a few yards of the fault plane suddenly steepen up to 30°. What I take to be the plane of the fault is marked by a seam of clay flucan, at a point two chains easterly from the peg at the foot of the hill shown on the line of section (*Plate 17*). The clay flucan is seen in the cutting of the new road now in course of construction. The seam is about six inches wide and is nearly vertical with apparently a slight dip to the west.

The Wianamatta Shales make their appearance again, on the downthrow side of the fault at a distance of a little over a chain west of the road peg shown on the section (*Plate 17*). A restoration of the eroded strata on the upthrow side of the fault as shown by the dotted area on *Plate 17*, shows the amount of throw of the fault as well as the minimum amount of erosion which has taken place since the faulting. The throw is probably at least 423 feet, as calculated from the survey by Mr. Halligan and myself, while the displacement due to bending and 'drag' of the strata on the opposite sides of the fault plane may amount to a maximum of 100 feet. The total displacement due to

bending and shearing thus amounts to probably over 500 feet. It may be added that on December 14th, Mr. Pittman and I found evidence of this fault being strongly developed at a locality called the Mountain Lagoon about 5¼ miles N. 3° E. from the foot of the "Cut Rock." (See plan, *Pl. 16.*)

The Wianamatta Shales are strongly developed on the downthrow side of the fault at the Mountain Lagoon, and it is clear that the lagoon owes its origin to the fault. On the upthrow side of the fault the Wianamatta Shales have been completely denuded away, so that accurate measurements of the throw could not be made by us there. It is clear, however, that the throw is fully 400 feet, as determined by aneroid measurements. There appears to be less bending of the strata as they approach the fault plane at the Mountain Lagoon than at the Cut Rock, for within 30 yards easterly of the fault plane at the former locality the dip is north-easterly at a low angle, that is in a direction *away* from the fault plane. It is evident from the configuration of the country that the fault extends at least as far north as the Colo River. The fault plane has not yet been traced by me to the south of the Cut Rock, but it is evident from the trend of the strong escarpment for many miles to the south that the fault must extend at least as far south as the Grose Valley, and probably as suggested earlier in this paper, extends to the westerly flexure at Glenbrook Railway Station. The total distance from Glenbrook Railway Station to the Colo River is about 27 miles. If now the Kurrajong Heights structures be compared with those of Lapstone Hill, it may be stated that at Kurrajong Heights the easterly monocline displaces the strata about 1,060 feet, measured vertically from the horizontal, and lowers them about 860 feet below their original position due to normal easterly dip, the figures for similar displacements at the Lapstone Hill monocline being respec-

tively 400 feet and 350 feet. The fault and slight westerly fold at the Cut Rock displaces the strata by 523 feet measured vertically from the horizontal, and about 530 feet below the original position of the strata due to easterly dip, whereas the displacements for the westerly fold at Glenbrook are about 100 feet from the horizontal, and about 175 feet from the calculated original plane of the strata before the folding. Thus whereas at both the Glenbrook and Kurrajong areas the easterly displacements are just double the westerly displacements, the total aggregate displacement at the Kurrajong is a little over double the aggregate displacement in the Glenbrook area.

Mr. Card and I traced the subsidence area in a westerly direction from the foot of the Cut Rock for four miles, and on December 13th Mr. Pittman and I followed it past Norwood (Bilpin) and old Tomah to the foot of Mount Tomah, where the subsidence area terminates in a monoclinal fold which effects a depression of the strata in an easterly direction of about 250 feet. The Wianamatta Shales are almost continuous from the foot of the Cut Rock to the foot of Mount Tomah. At the latter locality they have been eroded away at the base of the monocline, but reappear at a higher level as shown on *Plate 16.* They attain a thickness at Mount Tomah of from 100 to 150 feet, and are capped by a sheet of basalt having a maximum thickness of about 170 feet (see *Plate 16*). The total width of the subsidence area from west to east, between Mount Tomah and Kurrajong Heights measures about 11 miles. Its northern limit has yet to be discovered, but in the present state of our knowledge it may be safely stated that it has a length in a north and south direction of between 20 and 30 miles.

Obviously the existence of this fault at the Kurrajong will have an important bearing on the laying out of coal

mines when coal comes to be worked in the vicinity, and it is satisfactory to hear that the Geological Survey of New South Wales will map the course of the fault and the eastern fold, and show their further extent on the geological map, now being prepared, of the Sydney and Blue Mountain areas. From a geotectonic point of view the fault and monocline are interesting illustrations of the principle enunciated by Suess,[1] that where lateral pressure has produced a monoclinal fold, faulting usually takes place on the *inner* limb of the fold, (*i.e.*, on the portion nearest to the direction from which the folding force is coming) after the folding force has ceased to act, such faulting resulting in downthrows of the inner limb.

It would appear that the first stage in the evolution of these geotectonic structures in the portion of the Blue Mountains discussed in this paper was the formation of the chief monocline between Kurrajong Heights and Lapstone Hill, with the concurrent sinking of the coastal plane between Penrith and the sea. It is not yet clear whether the forming of the monocline at Mount Tomah was contemporaneous with the preceding or took place earlier or later. The folding force came from a westerly direction, and it pushed the strata eastwards forming the steep easterly slopes of the Kurrajong and Lapstone Hill, a slight fold facing the west developing to the west of this eastern monocline. After the folding force had become less intense or had ceased, a fracture formed along this western fold, the plateau to the west subsiding over 400 feet as the result, while the development of the monocline at Mount Tomah depressed the western portion of the plateau by a vertical amount of about 250 feet.

The fact that the top of the eastern monocline eventually attained to three times the height (1,964 feet) above sea-

[1] Das Autlitz der Erde, Vol. I., p. 142—307.

level at the Kurrajong as at Lapstone Hill (620 feet) explains why the Grose River has been pushed further and further south, the water naturally making for the lower end of the embankment or fold, just as when a dam is thrown across a river flowing from west to east, if the north end of the dam is higher than the southern end the river will establish a bywash for itself over the lower end of the dam, which in this case would lie on the south side of the valley. The above I think is a reasonable explanation of the great bend towards the south-east in the Grose River as it sweeps through the parishes of Grose, Burralow, and Coomassie just before it crosses the line of fold. It will be noticed on reference to the map (*Plate 16*) that there are bends, almost concentric to this river bend, in the main line of water parting to the north of the Grose Valley near Bilpin (on 'Bell's Line') and on the main water parting to the south, viz., the line of the Main Western Road and Western Railway. (See plan, *Plate 16.*)

Suggestions for further explorations.—Obviously a very important question to be further studied in connection with the subsidence area between the Kurrajong and Mount Tomah, is its relation to the volcanic outbursts of Mounts Tomah, Bell, Hay, Tootie, Irvine, King George, Wilson, etc. Basalt is said to occur close to the fault plane at the 'Mountain Lagoon,' and this should be worth examining to determine its relation to the faulting.

The points where the fault crosses the Grose and Colo Valleys should be worth exploring, and in these valleys, as well as in that of Wheeny Creek, search might be made for the chocolate shales, the topmost beds of the Narrabeen Series, (the third and lowest member of the local Trias). An explanation is much needed of the remarkable horizontal displacement of the fold and fault as they cross the Grose Valley. The question also suggests itself, was the fault-

ing sufficiently rapid to produce a lake on the downthrow side in either the Grose or Colo Valleys? if so, traces may be found of such lacustrine beds. On the contrary, the faulting may have been so slow that the Grose and Colo Rivers may have been able to deepen their channels on the upthrow side of the fault at a rate sufficiently rapid to keep pace with the subsidence on the downthrow side.

Age.—As regards age it is clear from the large amount of denudation which the upthrow side of the fault plane has undergone at Kurrajong Heights (see left of *Plate 17*) that the fault cannot be very modern. Since the faulting occurred a large wedge-shaped slice has been worn off the upthrow side of the fault, and this measures in places 500 feet thick, about 14 chains wide, and about 20 miles long. The above, it may be added, is a low estimate of the amount of denudation subsequent to the faulting, as the Wianamatta Shales at the time of the faulting probably had a thickness of at least 100 feet, whereas in the above estimate a thickness of only 20 feet has been assumed for them.

In conclusion I beg to thank Mr. Halligan for his kindness in surveying the present slopes near the fault plane, and Messrs. G. E. Collett and W. G. Woolnough, B.Sc., F.G.S. for assisting in the work. The Road Superintendent, Mr. Norman Grant, gave useful assistance by placing the services of his foreman at our disposal. Mr. E. F. Pittman kindly examined all the sections in the field with me, and joined with me in the collecting of evidence for drawing *Plate 16*, and I am much indebted to him for his help and criticism. Mr. G. W. Card, was good enough to assist me with his aneroid observations; and I desire to thank my colleague, Mr. W. S. Dun, F.L.S., for kindly supplying bibliographical references.

Fig. 1—The Boogaldi Meteorite, N.S.W. Showing "drip" from the underside, tail end. Length 5 inches, width 3 inches; weight 2057·5 grms. Sp. gr. 7·85.

Fig 2—Boolgaldi Meteorite, N S W The lower side is on the right hand.
* This indention is due to the support on which the meteorite rested

Fig. 3—The Boogaldi Meteorite, N S W Showing waves formed in the fluid skin at the forward end, the right hand side was the lower one during flight Enlarged 2 diameters.

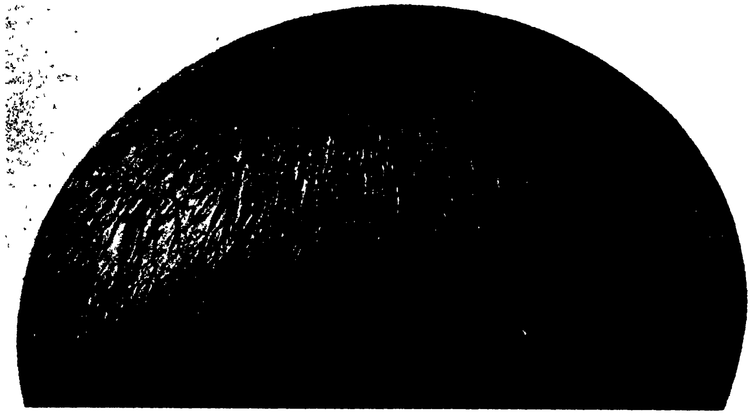

Fig. 4—Boogaldi Meteorite, N.S.W. Showing the flow of the oxides at the lower side of the forward end; also pit on the right.

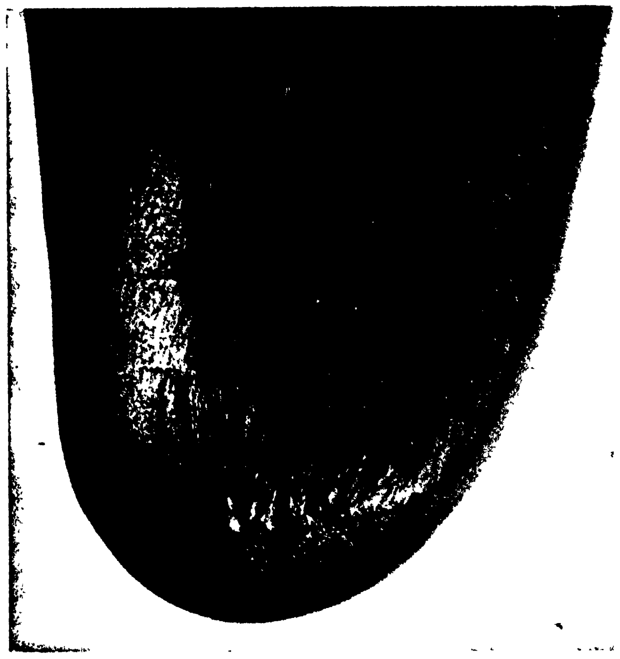

Fig. 5—Boogaldi Meteorite, N.S.W. Showing the drip of the fluid oxides from the lower side of the tail end of the meteorite.
Figs. 4 and 5 are somewhat enlarged.

Fig. 6—Section of the Boogaldi Meteorite, N. S. W. Length 5 inches, width 3 inches.

Fig. 7—Barratta Meteorite No. 2, N.S.W. Weight 31½ lbs. Reduced to about ⅘. Specific gravity 3·706.

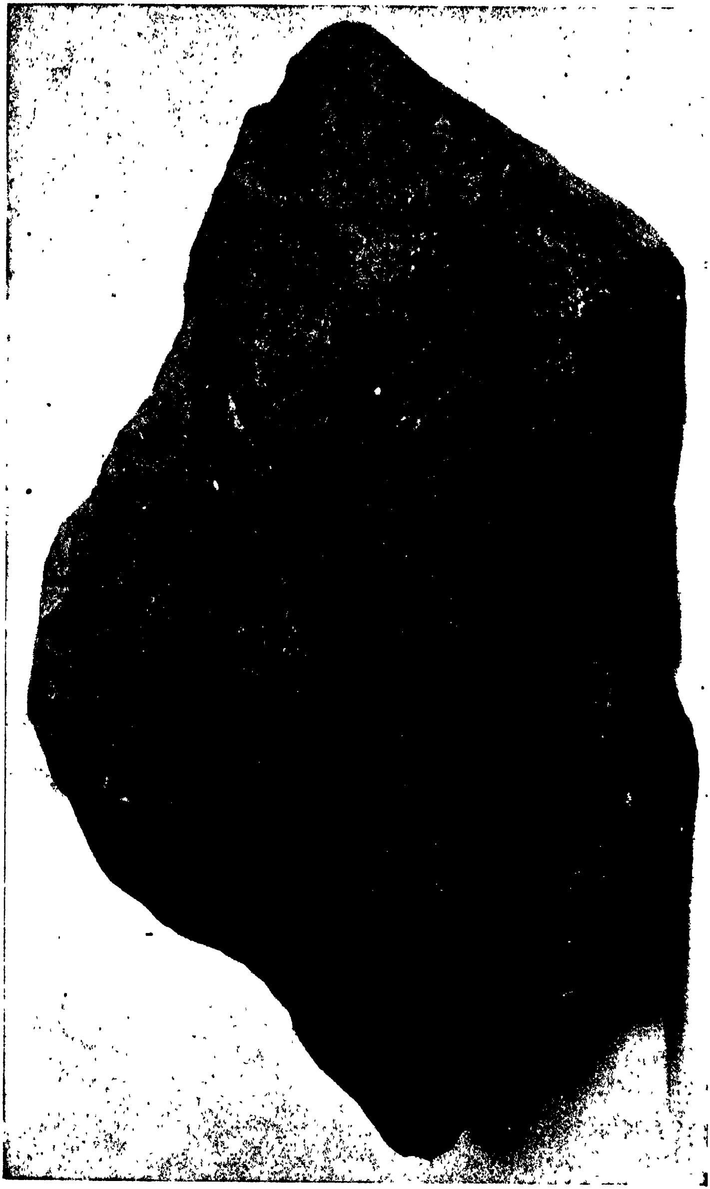

Fig. 8—Barratta Meteorite, No. 3, N.S.W. Weight 48 lbs. Reduced to $\frac{1}{2}$. Specific gravity 3·429.

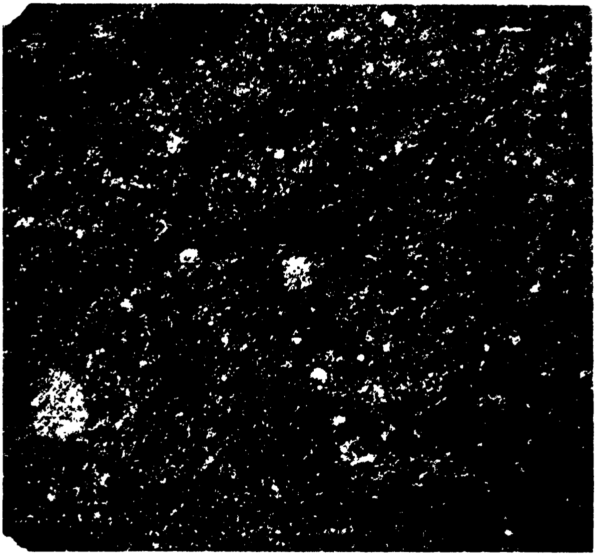

Fig. 9—Fractured Surface of Barratta Meteorite No. 2. 2 diameters.

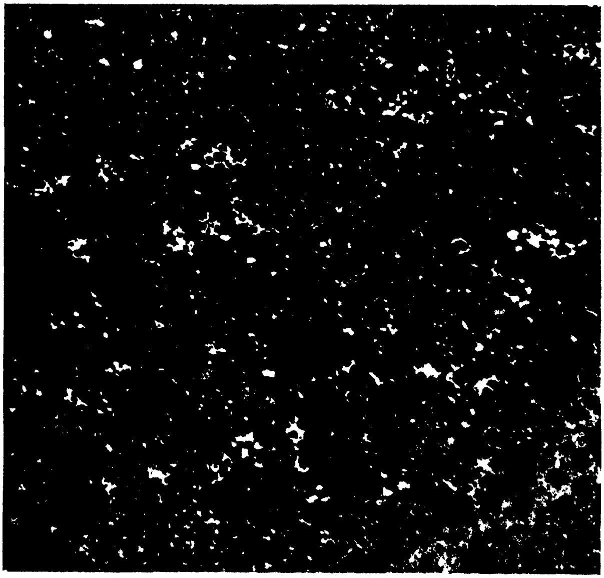

Fig. 10—Barratta Meteorite No. 2. 2 diameters. Polished Surface, the white markings are metallic particles.

Fig. 11—Section of Barratta Meteorite No. 2. 12 diameters.

Fig. 12—Section of Barratta Meteorite No. 3. 16 diameters.

Fig. 13—Section of Gilgoin Meteorite No. 1. 12 diameters.

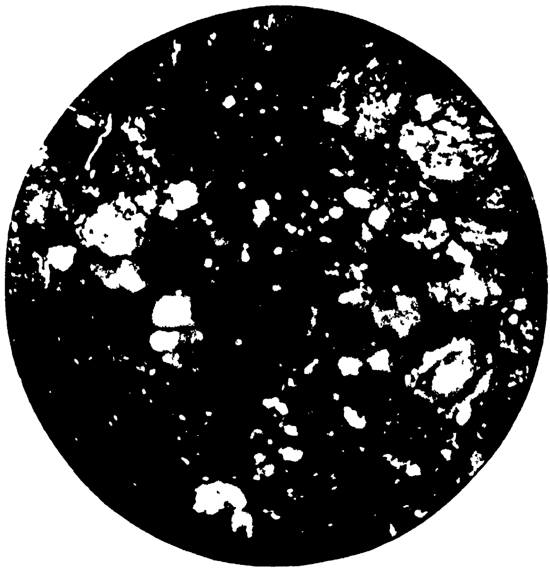

Fig. 14—Section of Hay or Eli Elwah Meteorite. 12 diameters.

Fig. 15—Gilgoin Meteorite No. 1, N.S.W. Reduced to nearly ¼. Weight 67½ lbs. Specific gravity 3·857.

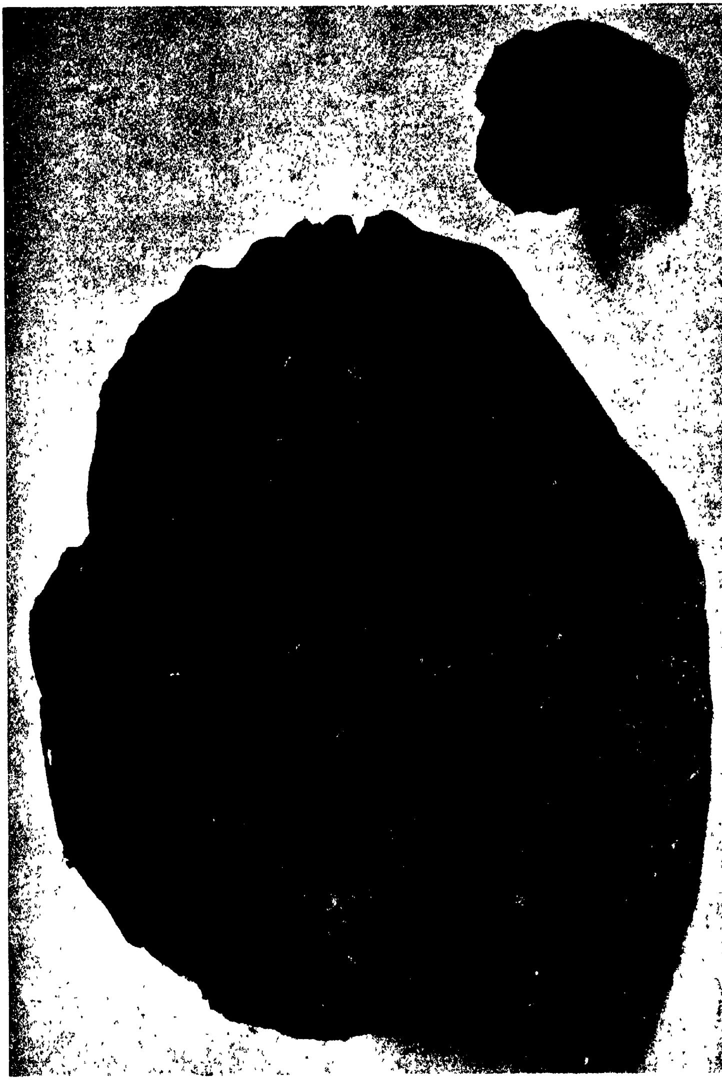

Fig. 16—Gilgoin Meteorite No. 2, N.S.W. Reduced to nearly ¼. Weight 74 lbs. 4 ozs. Specific gravity 3·757.

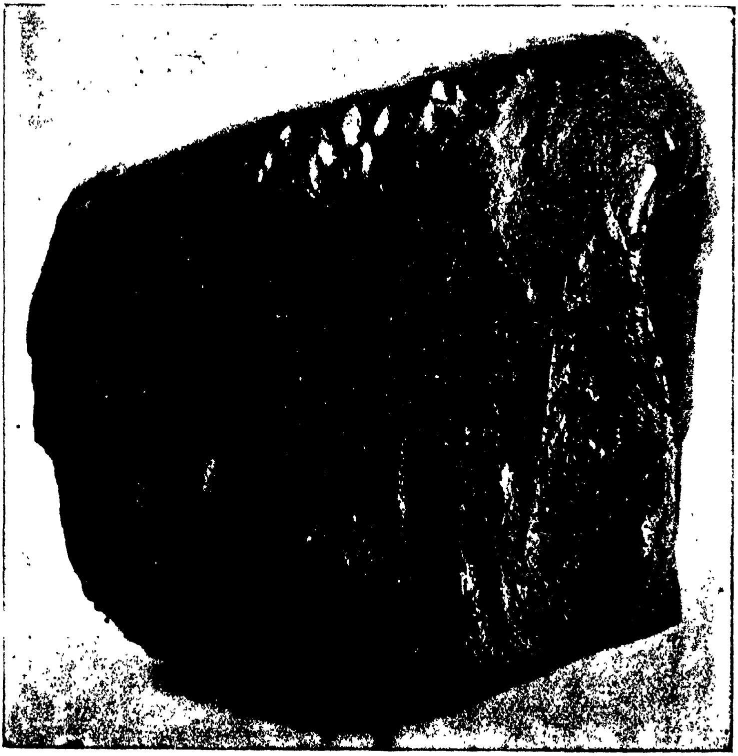

Fig. 17—Eli Elwah or Hay Meteorite, N.S.W. Reduced to ½. Weight 33½
Specific gravity 3·537·

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 7, 1902.

The Annual General Meeting of the Society was held at the Society's House, No. 5 Elizabeth Street North, on Wednesday evening, May 7th, 1902.

The President, H. C. RUSSELL, B.A., C.M.G., F.R.S., in the Chair.

Upwards of one hundred members and visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ended 31st March, 1902, was presented by the Hon. Treasurer, and adopted:

GENERAL ACCOUNT.

RECEIPTS.		£	s.	d.	£	s.	d.
Subscriptions	One Guinea	91	7	0			
	Two Guineas	367	10	0	540	18	3
	Arrears	82	1	3			
Parliamentary Grant on Subscriptions received—							
Vote for 1901-1902		500	0	0			
					500	0	0
Rent...					38	0	0
Sundries					19	13	6
Clarke Memorial Fund					300	0	0
Total Receipts					1398	11	9
Balance on 1st April, 1901					53	13	10
					£1452	5	7

Payments.	£ s. d.	£ s. d.
Advertisements ...	28 7 0	
Assistant Secretary ...	250 0 0	
Books and Periodicals ...	78 2 4	
Bookbinding ...	24 11 9	
Conversazione ...	73 3 11	
Collector ...	3 11 5	
Freight, Charges, Packing, &c....	7 11 6	
Furniture and Effects ...	24 16 9	
Gas ...	19 17 2	
Housekeeper ...	10 0 0	
Insurance ...	10 0 8	
Interest on Mortgage ...	56 0 0	
Office Boy ...	20 11 10	
Petty Cash Expenses ...	13 3 3	
Postage and Duty Stamps ...	35 10 0	
Printing ...	28 17 0	
Printing and Publishing Journal ...	270 6 11	
Printing Extra Copies of Papers ...	9 14 6	
Rates ...	41 15 0	
Reception ...	1 3 11	
Refreshments and attendance at Meetings ...	26 7 6	
Repairs ...	11 11 9	
Stationery ...	10 6 11	
Sundries ...	37 5 5	
Total Payments ...		1092 16 6
Repayment to Clarke Memorial Fund... ...		300 0 0
Balance on 31st March, 1902, viz.:—		
Cash in Union Bank, General Account ...	41 8 7	
„ „ B. & I. Fund ...	8 0 6	
Cash in hand... ...	10 0 0	
		59 9 1
		£1452 5 7

BUILDING AND INVESTMENT FUND.

Receipts.	£ s. d.
Loan on Mortgage at 4% ...	1400 0 0
	£1400 0 0

Payments.	£ s. d.
Advance to General Account 31st March, 1897 ...	8 0 6
Balance 31st March, 1902 ...	1391 19 6
	£1400 0 0

CLARKE MEMORIAL FUND.

Receipts.	£	s.	d.
Amount of Fund, 31st March, 1901	432	17	1
Interest to 31st March, 1902	11	13	11
	£444	11	0

	£	s.	d.
Deposit in Savings Bank of New South Wales, March 31, 1902	218	19	0
Deposit in Government Savings Bank, March 31, 1902 ...	225	12	0
	£444	11	0

AUDITED AND FOUND CORRECT, AS CONTAINED IN THE BOOKS OF ACCOUNTS.

DAVID FELL, C.A.A.......... } *Honorary Auditors.*
LAWRENCE HARGRAVE }

SYDNEY, 24th April, 1902.

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB, *Assistant Secretary.*

His Honor Judge Docker and Mr. J. T. Wilshire were appointed Scrutineers, and Mr. D. Carment deputed to preside at the Ballot Box.

There being no other nominations, the following gentlemen were elected officers and members of Council for the current year.

President:
Prof. WARREN, M. Inst. C.E., Wh.Sc.

Vice-Presidents:
H. C. RUSSELL, B.A. C.M.G., F.R.S.
G. H. KNIBBS, F.R.A.S.
W. M. HAMLET, F.I.C., F.C.S.
Prof. LIVERSIDGE, M.A., LL.D., &c.

Hon. Treasurer:
D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:
J. H. MAIDEN, F.L.S.
F. B. GUTHRIE, F.I.C., F.C.S.

Members of Council:
Prof. T. W. E. DAVID, B.A., F.R.S.
HENRY DEANE, M.A., M. Inst. C.E.
J. W. GRIMSHAW, M. Inst. C.E.
H. A. LENEHAN, F.R.A.S.
CHARLES MOORE, F.R.B.S.
F. H. QUAIFE, M.A., M.D.
GEORGE E. RENNIE, B.A., M.D.
HENRY G. SMITH, F.C.S.
Prof. ANDERSON STUART, M.D., LL.D.
J. STUART THOM

The certificates of three candidates were read for the third time, of one for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Brereton, Victor Le Gay, Solicitor, "Osgathorpe," Gladesville.

Calder, Robert A., Dentist, 448 Castlereagh Street.

Hennessy, John Francis, Architect, City Chambers, 243 Pitt Street.

The following announcements were made:—

1. That the Officers and Committee of the Engineering and Economic Sections had been elected for the ensuing Session, and the dates fixed for their meetings, as follows:—

SECTIONAL COMMITTEES—SESSION 1902.

Section K.—Engineering.

Chairman—H. G. McKinney, M. Inst. C.E.

Hon. Secretaries—S. H. Barraclough, M.M.E., Assoc. M. Inst. C.E., H. H. Dare, M.E., Assoc. M. Inst. C.E.

Committee—Percy Allan, M. Inst. C.E., G. R. Cowdery, Assoc. M. Inst. C.E., J. Davis, M. Inst. C.E., Henry Deane, M. Inst. C.E., J. I. Haycroft, M.E., M. Inst. C.E., I., Herbert E. Ross, W. H. Warren, M. Inst. C.E., M. Am. Soc. C.E., J. H. Cardew, Assoc, M. Inst. C.E.

Past Chairmen, *ex officio* Members of Committee for three years:—T. H. Houghton, M. Inst. C.E., M. Inst. M.E., Norman Selfe, M. Inst. C.E., J. M. Smail, M. Inst. C.E.

Meetings held on the Third Wednesday in each month, at 8 p.m.

Economic Section.

Chairman—R. Teece, F.I.A., F.F.A.

Hon. Secretary—A. Duckworth.

Committee—J. W. Grimshaw, M. Inst. C.E., A. Halloran, B.A., LL.B., J. Henderson, Joseph Palmer.

Meetings held on the Fourth Wednesday in each month, at 8 p.m.

SECTION MEETINGS.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ENGINEERING—Wednesday, (8 p.m.)	21	18	16	20	17	15	19	17
ECONOMIC—Wednesday, (8 p.m.)	28	25	30	27	24	29	26	10

SCIENCE LECTURES.

2. That the series of Popular Science Lectures to be delivered during the present Session, will be as follows:

They will be delivered at the Society's Rooms, on the Fourth Thursday in each month, *i.e.*, on

June 30th—"THE RÔLE OF BACTERIA IN THE PRODUCTION OF DISEASE," F. Tidswell, M.B., M.Ch., D.P.H., Health Department.

July 24th—"THE DEVELOPMENT OF THE DWELLING HOUSE," F. W. Woodhouse, Superintendent of Drawing, Department of Public Instruction.

August 28th—"MICRO-ORGANISMS, THEIR LIFE AND WORK," R. Greig-Smith, M.Sc., Macleay Bacteriologist.

October 23rd—"BIOLOGY AND EVERY-DAY LIFE," Professor W. A. Haswell, M.A., D.Sc., F.R.S.

November 27th—"THE ART OF THE BRIDGE-BUILDER," Professor W. H. Warren, Wh. Sc., M. Inst. C E.

3. Ninety-seven volumes, 444 parts, 64 reports, and 120 pamphlets, total 725, received as donations since the last meeting, were laid upon the table and acknowledged.

The following letters were read:—

1620 P Street, N.W., Washington, D.C.,
3rd January, 1902.

The Hon. Secretary of the Royal Society of New South Wales,

Dear Sir—I have the pleasure to acknowledge receipt of your communication of November 12th, apprising me of my election as honorary member of your Society. This high honour coming from so distant as well as so distinguished a branch of the world of learning is, I assure you, very highly appreciated. I beg that you will convey to the Society both my thanks, and my wishes for its success in promoting science and learning in the Southern Hemisphere.

I am, dear Sir, yours most respectfully,
SIMON NEWCOMB.

---

22 Cumberland Road, Kew, Surrey,
26th December, 1901.

My dear Sir,—It was with great pleasure that I received your letter of the 12th ultimo, informing me of my election as an Honorary Member of the Royal Society of New South Wales. I have so many friends and former students in Sydney, and it has been such a pleasure to me to co-operate with them in working out the rich harvest of materials obtained at Funafuti, that I feel especial gratification at the honour you have done me. Will you express to the Society my thanks for the very great honour they have conferred upon me and believe me to be,

Yours very faithfully,
JOHN W. JUDD.

The Hon. Secretary, Royal Society of New South Wales.

2 Queen Square Place, Queen Anne's Mansions, Westminster, S.W.
18 January, 1902.

My dear Sir,—Your letter of the 12th November arrived here during my absence in Egypt on professional duties connected with the Nile Reservoir works, or I should have acknowledged its receipt before. Will you please convey to the Council of the Society my sincere appreciation of the great honour done to me in electing me an Honorary Member of the Society, whose good work is well known to myself and other engineers from the admirable papers from time to time published by the Society.

Yours faithfully,
BENJAMIN BAKER.

G. H. Knibbs, Esq., Hon. Secretary,
Royal Society of New South Wales.

Walreddon Manor, Tavistock, Devon,
March, 1902.

Dear Sir,—I write to acknowledge the safe arrival of the Clarke Medal awarded to my dear distinguished husband by the Council of the Royal Society of New South Wales. The medal arrived *after* Mr. Eyre's death, I grieve to say, for it would have been a great satisfaction to him to have seen it. I, his sad widow, offer my heartfelt thanks to the Council for this tribute to my husband's praise, and for their expressions of appreciation of his splendid work in Australia. I have been ill, and in too great affliction to be able to write before. The medal is very beautiful and will be kept as an heirloom in the family.

Very faithfully yours,
ADELAIDE FANNY EYRE.

Financial Position.—The Hon. Treasurer's Financial Statement shows that the financial affairs of the Society are in a fairly satisfactory condition.

The Library.—From the Balance Sheet submitted this evening it will be seen that the sum of £78 2s. 4d. was spent upon books and periodicals, and £24 11s. 9d. for binding during the past year.

Exchanges.—Last year we exchanged our Journal and Proceedings with 420 kindred Societies, receiving in return 333 volumes, 1,608 parts, 179 reports, 280 pamphlets, 2 maps, 12 geological and topographical maps, 2 geological photographs, 1 physical atlas, 1 hydrographic atlas, 4 hydrographic charts and 3 meteorological charts; total 2,425.

The Library of the British Museum (in addition to the Museum of Natural History) has been placed on the exchange list.

Papers read in 1901.—During the past year the Society held eight meetings, at which 19 papers were read; the average attendance of members was 40, and of visitors 3.

Sections.—The *Engineering Section* held six meetings during the year, at which five papers were read and seven discussed; the average attendance of members and visitors was 16.

The *Economic Science Section* held five meetings during the year, at which seven papers were read and discussed.

Lectures.—A course of five science lectures was delivered during the Session, and were well attended.

Roll of Members.—The number of members on the Roll on the 30th April, 1901, was 368. During the past year 20 new members were elected; the deaths numbered nine, and the resignations four, leaving a total of 375 on the 30th April, 1902.

Obituary.—The following is a list of members who have died during the year 1901:—

Honorary Members.

Elected

1878, Agnew, Sir James, K.C.M.G., M.D.
1888, Tate, Professor Ralph, F.G.S., F.L.S.

Ordinary Members.

1864, Adams, P. F.
1877, Abbott, The Hon. Sir J. P., K.C.M.G., M.L.A.
1894, Carleton, H. R.
1878, Colquhoun, George.
1880, Cox, Hon. G. H., M.L.C.
1868, Garran, Hon. Dr. Andrew.
1879, Stephen, Hon. S. A.
1876, Tibbits, Dr. W. H.
1872, Wright, Dr. H. G. A.

Mr. Russell expressed his regret that, owing to ill-health during the past year and to the pressure of his official duties, he had been quite unable to prepare a Presidential Address; he then vacated the chair.

On the motion of Mr. J. T. Wilshire, a vote of thanks to the retiring President was carried with acclamation.

Professor Warren, having been installed as President, thanked the members for the honour conferred upon him.

The meeting then resolved itself into a "Reception," or informal Conversazione.

Various interesting exhibits were shown by the following gentlemen:—Mr. H. C. Russell, Prof. A. Liversidge, Prof. David, Dr. F. H. Quaife, His Honor Judge Docker, Mr. J. H. Maiden, and others.

ABSTRACT OF PROCEEDINGS, JUNE 4, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 4th, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

About seventy members and visitors were present.

The minutes of the preceding meeting were read and confirmed.

Mr. R. A. Calder enrolled his name and was introduced.

Mr. Harrie Wood and His Honor Judge Docker were appointed Scrutineers, and Dr. F. H. Quaife deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

Wright, John Robinson; Fairfield.

The certificate of one candidate was read for the third time, of three for the second time, and of one for the first time.

The President announced that the first Science Lecture for the present Session would be delivered on the 30t inst. by Dr. Frank Tidswell, M.B., M.Ch., D.P.H., Health Department, on "The Rôle of Bacteria in the Production of Disease."

Twenty-six volumes, 144 parts, 11 reports, 19 pamphlets and 1 hydrographic chart, total 201 received as donations since the last meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:—

1. "The Parks of Sydney; some of the problems of control and management," by J. H. MAIDEN, F.L.S., Director of Botanic Gardens and Domains, Sydney; Officer-in-Charge of the Centennial Park.

I. General questions:
- *a.* Introductory.
- *b.* Sydney Parks,—how vested and controlled.
- *c.* Sydney Parks,—Statistics.
- *d.* Park lands should be inalienable.

II. Police and traffic regulation.
- *a.* Police.
- *b.* Traffic regulation.

III. Roads and paths; fences; seats, etc.
- *a.* Roads and paths.
- *b.* Fences.
- *c.* Seats.

IV. Plantations; grass, etc.
- *a.* Plantations.
- *b.* Grass.
- *c.* Depasturing of Stock.

V. Buildings etc., in and abutting on Parks.
- *a.* Buildings.
- *b.* Wharves.

VI. Special public requirements :—
- *a.* Necessities :—
  1. Lighting.
  2. Sanitation.
  3. Water-supply.
  4. Public-baths and boat-sheds.
  5. Refreshments.
- *b.* Luxuries.
  1. Games, etc.
  2. Music.
  3. Statuary.

2. "A possible connection between Volcanic Eruption and Sunspot Phenomena," by H. I. JENSEN (communicated by Professor DAVID, B.A., F.R.S.)

The author of this paper mentions that the idea of the existence of such a connection was suggested to him by the fact that Vesuvius was in violent eruption in the years 1813, 1822, 1855, 1867. 1891, and 1900, all of which were minimum years. By means of a chart he shows that earthquakes and eruptions are most violent, numerous, and extensive when there is least sunspot activity. Though seismic disturbances do occur at all times, they seem for the last one hundred and twenty years to have been most severe around the minimum years :—1811, 1822, 1833 - 4, 1844, 1855 - 6, 1867 - 8, 1878 - 9, 1888 - 9, and 1900 - 2, large groups of great earthquakes and eruptions having taken place in and about these years. On the other hand the chart also shows that in years of maximum, like 1893 - 8, 1884 - 5, 1869 - 71, 1858 - 65, and so on, these phenomena have been comparatively few and unimportant.

The writer thinks that the cause of this connection between solar and seismic disturbances, is that in years of sunspot minimum there is less heat, and other energy, received from the sun, and consequently there is more rapid radiation from the earth, causing quicker cooling, hence more cracking of the earth's crust. He also suggests that the earth's atmosphere exerts a greater squeeze on the

crust in years of minimum, thus forcing lava out of fissures. He quotes the statements of various meteorologists, who are of opinion that the average barometric pressure at the earth's surface for years of sunspot minima is greater than in maxima years, and that the mean temperature is at the same time lower.

If the connection which this paper tries to prove is found by future researches to be real and not merely accidental, the writer thinks that it should be possible to forecast earthquakes, though he admits the necessity of considering many other factors closely, for example secular contraction, perigee, perihelium, and atmospheric conditions, which undoubtedly affect, to a smaller extent than sunspots (the writer thinks), volcanic and seismic phenomena.

EXHIBITS.

1. Numerous coloured diagrams and maps illustrating Mr. Maiden's paper on "The Parks of Sydney."

2. In the absence of the exhibitor (Mr. C. A. Süssmilch) Prof. David described the following specimens:—(*a*) Beekite on fossil coral *(Mucophyllum)* from Spring Creek, (*b*) specimens of *Lingula gregaria* from Devonian rocks at Nyrang Creek.

3. Prof. David exhibited specimens of "Tinguaite," a rather rare variety of nepheline ægirine rock from Barigan near Lue, N. S. Wales, discovered by J. E. Carne, F.G.S., of the Geological Survey of N. S. Wales.

ABSTRACT OF PROCEEDINGS, JULY 2, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 2nd, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Thirty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. J. T. Wilshire and Norman Selfe were appointed Scrutineers, and Mr. W. M. Hamlet, deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—

Faithfull, William Percy, Barrister-at-Law, Australian Club.

Richard, G. A., Metallurgical Engineer, Mount Morgan Gold Mining Co., Mount Morgan, Queensland.

Welsh, David Arthur, Professor of Pathology, Sydney University, Glebe.

The certificates of three candidates were read for the third time, of one for the second time, and of three for the first time.

The President announced that the second Science Lecture for the present Session would be delivered on the 24th inst. by F. W. WOODHOUSE, Esq., Superintendent of Drawing, Department of Public instruction, on "The Development of the Dwelling House."

Thirty-one volumes, 171 parts, 6 reports, and 9 pamphlets total 217 received as donations since the last meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:—

1. "Notes on two chemical constituents from the Eucalypts," by HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum.

In this paper the author records the results of continued investigations on the ester (geranyl-acetate) contained in the oil of *Eucalyptus Macarthuri*, Deane and Maiden, and also on the oil itself. This data shows that the ester does not fall, at any time of the year, below 60%, and that the amount of free alcohol, considered as geraniol, diminishes in amount as the ester increases. The greatest amount of naturally formed esteroccurring at any time of the year was 74·9% in September, but the free alcohol wasonly 6% at that time. It has been found from numerous determinations that when the oil is acetylised the ester content will be but little removed from 80%. The oil does not contain phellandrene at any time of the year, and eucalyptol appears to be always absent. Eudesmol is always present, but as it varies in amount, the specific gravity of the oil varies also. The crude oil appears to be always slightly dextro-rotatory. From the results of investigation of the oil obtained from over 100 distinct species of Eucalypts, this is the only one found to contain this valuable oil. The author also shows that the original formula for the quercetin glucoside, myrticolorin ($C_{27}H_{28}O_{16}$) obtained from the leaves of *Eucalyptus macrorhyncha* was correct (Trans. Chem. Soc. 1898, p. 697). This formula has been confirmed by Mr. A. G. Perkin, who has shown (Trans. Chem. Soc. 1902, p. 477) that his own osyritrin, and also Mandelin's violaquercitrin have the same formula, and are identical substances with myrticolorin. They all form quercetin and glucose on hydrolysis.

2. "The aboriginal languages of Victoria," by R. H. MATHEWS, L.S.

The paper was read by Mr. J. H. Maiden in the unavoidable absence of the author. Synopsis:—Introductory,

Orthography; the Tyattyalla language; the Tyapwurru and Wuddyauro dialects; the Thaguwurru language; the Woi-wurru dialect; the Kunnai language; vocabulary of Tyattyalla and Kunnai words.

3. "The Parks of Sydney; some of the problems of control and management," by J. H. MAIDEN, F.L.S., Director of Botanic Gardens and Domains, Sydney; Officer-in-Charge of the Centennial Park.

This paper was read at the June meeting. A discussion ensued in which the following gentlemen took part:—Messrs. J. T. Wilshire, C. A. Benbow, P. N. Trebeck, H. Deane, C. O. Burge, Dr. T. Storie Dixson, Mr. A. Duckworth and Dr. F. H. Quaife. Mr. Maiden replied.

The following is an abstract of the first Science Lecture of the present Session, delivered on the 30th June by F. Tidswell, M.B., M.Ch., D.P.H., Health Department, on "The Rôle of Bacteria in the Production of Disease."

The lecture opened with an account of the discovery of bacteria over two centuries ago by the Dutchman Anton van Leeuwenhoek. Allusion was then made to the subsequent controversies concerning the origin of bacteria, and their influence in causing disease, and the manner in which their final settlement was effected by the researches of Louis Pasteur some thirty years ago. Attention was then directed to Pasteur's demonstration of the causal micro-organism of a disease affecting silkworms, and of Davaine's observations on the microbe of anthrax. It was shown how these results stimulated investigation of the germ theory, and how the proof of its correctness was rendered possible by the elaboration of exact bacteriological methods by Robert Koch. Mention was then made of the species of bacteria which produce disease in man. There followed a brief accouut of the structure and functions of bacteria

in general, and the specialisation of some forms into producers of disease. The consideration of the occurrence of these bacteria in the surroundings of the sick, and even upon the healthy skin, led up to an account of Lister's institution of methods for preventing their entry into wounds, and its development into the modern system of aseptic surgery and of the principles underlying the hospital isolation of the infectious sick, and disinfection. The means by which infectious bacteria gain access to the surface of the body, and the events connected with their entrance to, and development in the internal tissues were dealt with at length. It was pointed out that the manifestations of these diseases depend upon the injury done to the tissues by the poisons or toxins produced by the bacteria, and that recovery from them is consequent on the elaboration of neutralising substances or antitoxins by the cells of the body. Reference was then made to the after effects of these diseases, including the immunity against subsequent attacks, and in this connection attention was called to the use of viruses, vaccines, and prophylactics as preventives and of antitoxic serums as cures for infectious diseases.

ABSTRACT OF PROCEEDINGS, AUGUST 6, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 6th, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Thirty-eight members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. T. F. Furber and M. Canty were appointed Scrutineers, and Mr. H. A. Lenehan deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

Warren, Ernest William, B.E., B.A., LL.B., Barrister-at-Law; Wentworth Court.

The certificate of one candidate was read for the third time, and of three for the second time.

The President announced that the third Science Lecture for the present Session would be delivered on the 28th instant, by R. GREIG SMITH, M. Sc., Macleay Bacteriologist, on "Micro-organisms, their Life and Work."

Sixteen volumes, 129 parts, 12 reports, and 10 pamphlets, total 167 received as donations since the last meeting were laid upon the table and acknowledged.

The paper on "Sunspot minima and Volcanic Eruptions" by Mr. H. I. JENSEN (communicated by Prof. T. W. E. DAVID, B.A., F.R.S.) and read 4th June, 1902, was then discussed, the following gentlemen taking part Dr. A. M. Megginson, Dr. Walter Spencer, Prof. David, Mr. H. C. Russell, the author and the Chairman.

THE FOLLOWING PAPER WAS READ :—

On "The Mitigation of Floods in the Hunter River," by J. H. MAIDEN, F.L.S.

The paper discusses the subject from the point of view of the forester.

I. Introductory.
II. Geographical notes.
III. The situation,—denudation.
The outlook serious.
IV. Intelligent control of ringbarking the beginning of all remedial measures :—
a. Shelter for stock should be adequate.
b. Danger of cutting trees too near the water-courses.

V. Deviation of roads.
VI. Falling in of banks.
VII. Floods and weeds.
VIII. Some miscellaneous factors in erosion:—
- *a.* Boulders.
- *b.* Dead trees.
- *c.* Stock.

IX. Remedial and preventive measures:—
- *a.* Control of ringbarking.
- *b.* Fencing.
- *c.* Embankments.
- *d.* Chamfering of banks.
- *e.* Planting and conservation.
    1. Natural bank protectors.
    2. Other bank-protectors (exotic).
    3. Plants recommended for Upper, Middle, and Lower Hunter.
    4. Nurseries.

X. Summary of the measures recommended for mitigation of floods.
Appendix 1. Mountain torrents in Europe.
Appendix 2. Lessons to be learnt from some rivers in Europe.
Appendix 3. An instance of denudation in the United States.

It was decided to discuss the paper at the meeting of 3rd September.

EXHIBITS.

1. Columnar Basalt *in situ* from Stirling, near Inverell, New South Wales, columns minor diameter 9 in. to 26 in., lengths not known, but apparently 10 to 20 ft. Very dense, compact, stones, separated by clay joints of $\frac{1}{8}$ in. thickness, by Mr. HERBERT E. ROSS.

2. Specimens of 'Fire Stone' from Saunders' Quarries, Pyrmont, by Mr. HENRY DEANE, M.A., M. Inst. C.E.

The following is an abstract of the second Science Lecture of the present Session, delivered on the 24th July, by Mr. F. W. WOODHOUSE, Superintendent of Drawing, Department of Public Instruction.

The history of man's dwellings is the record of his wants or absence of wants, of his ideas of comfort and decency, of his social position, of his relations to his neighbours and

to members of other communities. The earliest may be classed as permanent, temporary or portable, the necessities of agriculture developing the permanent and thus supporting Xenophon's assertion that "Agriculture is the Mother of the Arts." Passing to the sources of our information, we have, besides actual remains, the evidence of modern uncivilised peoples, of tombs and burial urns, of laws, charters, customs and traditions. The earliest form probably the round, like a wigwam. 'Beehive' huts of stone covered with a mound of earth are found in Greece and Britain and are still in use in the Hebrides. The round form, being inconvenient, disappeared as a usual dwelling-house, but from its survival as the 'fire-house' of the tribe and then of the homestead and its connection with hearth worship, its form was taken in Rome by the circular temples of the Hearth-goddess. The rectangular form probably derived from the use of 'forks' or pairs of inclined poles supporting a ridge. Confining our attention to the dwellings of Aryan races we may take first those of the pre-Hellenic Greek, which may be broadly denominated 'Mycenæan.' The general arrangement is based on an open court or farmyard with the dwelling opposite the entrance and stables, etc., on either side. In Hellenic Greece the court-yard plan became, in town houses, the 'Peristyle' with rooms around. The women were secluded in apartments lying beyond, in large houses round a second court. The Etruscan house was originally a single room with a square opening in the roof as exit for smoke. The Roman adopted the Etruscan 'Atrium' and the Greek 'Peristyle,' and generally built a second story over part of the ground floor. In Rome houses were generally let in 'flats,' and were of four or perhaps more stories, always a result of the limited space in walled cities. When we turn to our Saxon and Scandinavian ancestors we find the hall the nucleus of the dwelling; shared by the Saxon farmer with

his horses and cows. The bower or bedroom of the master is generally the only other room, servants and sons slept in the hall, and this even to the 14th Century. Progress in refinement is shown by the addition of parlours, bedrooms, separate dining-rooms, passages to connect rooms, until at last halls are built as a mark of state and dignity only. The progressive changes in windows and fireplaces may be taken as examples of the march of comfort and convenience. Stalls in markets were at first the only shops. Shops in houses were at first commonly half below the street level, being the cellar or store upon which the living rooms were raised. Since the Mediæval period, individualism has had full sway, subdivision of function marks our houses as it does all other phases of our complex and somewhat burdensome civilization.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 3, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 3rd, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Forty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. H. G. McKinney and T. F. Furber were appointed Scrutineers, and His Honor Judge Docker, deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—

Fleming, Edward Graham, Assoc. Memb. I. E Engineers, etc., Electrical Engineer; Australian Club.

Jevons, Herbert Stanley, Lecturer and Demonstrator, in Mineralogy and Petrology; University of Sydney.

Ramsay, Arthur Alex., Assistant Chemist, Department of Agriculture, 136 George-street, N.

The certificates of three candidates were read for the third time, and of two for the first time.

The President announced that the fourth Science Lecture for the present Session would be delivered on the 23rd October, by Professor W. A. Haswell, M.A., D.Sc., F.R.S., on "Biology and Every-Day Life."

Also that the Conversazione—which had been fixed for Thursday, September 25th—would unfortunately have to be postponed in consequence of the functions which were to take place at the University during the Jubilee week. The Conversazione would, however, be held at as early a date as the use of the Great Hall could be obtained, and due notice would be given to members.

Twenty-two volumes, 204 parts, 6 reports and 9 pamphlets, total 241, received as donations were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ :—

1. "Languages of some native tribes of Queensland, New South Wales and Victoria," by R. H. MATHEWS, L.S.

This paper dealt fully with the grammatical structure of the speech of the native tribes inhabiting the Murray River along the Victorian frontier, and stretching thence northerly through the central and western districts of New South Wales to the 29th parallel of latitude, and continuing onwards far into Queensland. The author stated that if this article be read in conjunction with a former contribution by him on "The Aboriginal Languages of Victoria," and

another on "The Thurrawal Language," it will be found to complete a description of the grammatical constitution of all the native tongues of New South Wales and Victoria.

2. "Current Papers, No. 7," by H. C. RUSSELL, B.A., C.M.G., F.R.S.

3. "Meteorological Notes," by H. C. RUSSELL, B.A., C.M.G., F.R.S.

The abstract of the above papers is postponed to next month.

4. "Meteoric Dusts, New South Wales," by Professor LIVERSIDGE, M.A., LL.D., F.R.S.

The term meteoric dust is used because it is commonly applied to the materials forming the subject of this paper; it is not intended to state that the dusts are necessarily of cosmic or extra terrestrial origin. The specimens described and exhibited were from Moruya, (fell on Dec. 15 1880); from Uralla, (fell on Dec. 14th, 1882); from near Broken Hill, (fell 1896); from Menindie (fell June 17th, 1899); and Pambula, (fell Oct. 5th, 1899). Dust from the roof-beams and mud from a covered cistern at the University and from the roof of the Observatory, Sydney; all three were collected in 1882. All the dusts are of a reddish colour except those from the University and Observatory. which are grey. The red dusts are mainly silicious and argillaceous, and look as if they had come from dried up water-holes, they contain a variety of organic and mineral matters such as might be expected from such a source, and in addition magnetite and metallic iron; the latter contains cobalt and nickel which seems to indicate that the dusts contain some cosmic or extra-terrestrial materials, part of which may have settled down and become mingled with the undoubted superficial terrestrial deposits and part may have been derived directly from the atmo-

sphere. The University and Observatory dusts also yielded magnetite and metallic iron containing cobalt and nickel, and the University dust yielded particles of gold, the Observatory dust has yet to be tested. The Moruya, Menindie and Barrier red dusts yielded particles of gold, the others have yet to be examined. Fuller information is given in the paper as to the constituents and chemical composition of the dusts, and anaylses of volcanic and other dusts for comparison.

Gold in Meteorites.—Prof. LIVERSIDGE also exhibited under the microscope particles of a malleable yellow metal, which have all the appearance of gold, obtained from certain Australian and European meteorites (siderolites). The presence of gold in meteorites bears upon the presence of gold in "meteoric" dusts, and it is also of great interest in connection with the presence of gold upon the earth and in sea-water, inasmuch as meteorites and the dust of meteorites are constantly falling upon the earth, to the extent of probably many million tons a year. Further information upon the question of the presence of gold in meteorites will be given shortly in a subsequent paper.

4. "A rapid gravimetric method of estimating Lime," by F. B. GUTHRIE, F.I.C., F.C.S., and C. R. BARKER.

The method consists in mixing previously dried and powdered ammonium nitrate with the calcium oxalate precipitate obtained in the usual manner. The oxalate is converted into calcium nitrate which is very readily and completely converted to oxide by a few minutes ignition over a bunsen burner. Prolonged ignition over the blowpipe is quite unnecessary, and effects no further alteration of the weight of the precipitate. Figures were given showing the accuracy of the method.

Remarks were made by Mr. Hamlet and Prof. Liversidge.

The paper on "The Mitigation of Floods in the Hunter River," by J. H. MAIDEN, F.L.S., read 6th August, 1902, was then discussed, the following gentlemen taking part:—Messrs. H. G. McKinney, J. B. Henson, C. O. Burge, H. Deane, J. H. Cardew, and Dr. F. H. Quaife. Owing to the lateness of the hour, the discussion was on the motion of His Honor Judge Docker, adjourned to the next General Monthly Meeting.

The following is an abstract of the third Science Lecture of the present session, delivered on the 28th August, by R. GREIG SMITH, M SC., Macleay Bacteriologist, upon "Micro-organisms; their Life and Work."

After a reference to the universal distribution of micro-organisms, the isolation of bacteria in the pure state was demonstrated by lantern slides. Then followed a description of the structure, shapes and methods of growth. The conditions which influence the life of bacteria such as aërobiosis and anaërobiosis, light, moisture and food supply were enumerated. The effect of temperature upon the growth of bacteria was illustrated by the putrefaction of food. The enormous multiplication of bacteria under the most favourable conditions, as well as the average multiplication under ordinary circumstances was indicated. The formation of spores by some bacteria was noted, and the resistance of these to disinfectants and to heat introduced the subject of pasteurisation and sterilisation. The various methods of sterilisation including intermittent and plasmolytic were described, and finally the action of disinfectants was discussed. In the distribution of bacteria, the parts played by water, air, dust, insects, and the coughing, sneezing, etc., of patients were summarized. The work that micro-organisms perform is made evident by the alteration of the medium in which they subsist. The bacteria of disease produce toxines, and in dealing with this branch

of the subject the formation of antitoxines and the phenomenon of phagocytosis as bearing upon immunity was briefly discussed. The micro-organisms of the industries produce bye-products of commercial importance; of these alcohol is the most important and its production by yeasts and moulds was described. Allusion was also made to the yeasts as producers of gas in bread baking and in certain aërated beverages. Then the alcohol consumers, the acetic bacteria were mentioned. This led to the production of other acids, especially lactic, the bacteria of which are used in the tannery and the dairy. The importance of the changes in the nitrogenous cycle—albumen, ammonia nitrate, albumen—to the agriculturist and the parts played in this cycle by bacteria were pointed out. A consideration of the secondary cycle—nitrate, nitrogen, albumen—introduced the question of the fixation of nitrogen. The similarity of the changes that occur in the soil and the aërobic treatment of waters and sewage was indicated, and the prolongation of the disintegration of sewage matter by storage in chambers before passing over the aërobic filters brought the lecture to a conclusion.

ABSTRACT OF PROCEEDINGS, OCTOBER 8, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 8th, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Forty-two members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. W. Percy Faithfull and A. Alexander Ramsay enrolled their names and were introduced.

The certificates of two candidates were read for the second time, and of one for the first time.

The President announced that the fourth Science Lecture for the present Session would be delivered on the 23rd October, by Professor W. A. HASWELL, M.A., D.Sc., F.R.S., on "Biology and Every-Day Life."

Also that the Conversazione (which had been postponed) would be held on Friday, December 5th, provided the use of the Great Hall of the University could be obtained on that date.

Sixty-one volumes, 119 parts and 25 reports, total 205, received as donations since the last meeting were laid upon the table and acknowledged. Included in the above were the Memoirs of the Royal Astronomical Society of London, Vols. V. — XL., (inclusive), completing the Royal Society's set with the exception of the first four volumes.

Correspondence from the Chief of the Department of Liberal Arts, World's Fair, St. Louis, U.S.A. 1803 — 1903, was read, and laid upon the table for information of the members.

The adjourned discussion of Mr. J. H. Maiden's paper on "The Mitigation of Floods in the Hunter River," (read August 6th) was continued and concluded, the following gentlemen taking part:—His Honor Judge Docker, Messrs. R. T. Baker, C. Moore, R. Helms, W. A. Dixon, and P. N. Trebeck. Mr. Maiden replied.

THE FOLLOWING PAPERS WERE READ:

1. "Occurrence of the mineral gadolinite at Cooglegong, Pilbarra District, West Australia," by BERNARD F. DAVIS, B.Sc. (Communicated by Prof. David, B.A., F.R.S.)

The specimen of gadolinite described in this paper was identified as such by Professor David and Mr. W. G. Woolnough, when it was brought over last year to Sydney University, by Mr. Bernard F. Davis. Mr. Davis kindly undertook to make an analysis of the mineral, and place the results at the disposal of the Royal Society of New South Wales. The mineral occurs in lodes, associated with tinstone and monazite contained in gneiss. It was found by Mr. Davis at Cooglegong, in the Pilbarra District, West Australia. The following is the analysis by Mr. Davis:—

SiO_2	23·33	Y_2O_3...	33·40
FeO...	10·38	MgO	·69
BeO...	12·28	Loss on ignition ...	·32
Ce_2O_3	2·50		———
La_2O_3 and Di_2O ...	18·30		101·20

Dr. Norman Collie examined the mineral for helium and other gases. He says that 10 grams on heating gave about 10 cc. of CO_2 and 10 cc. of hydrogen, a little nitrogen, and about one bubble of helium.

2. "Pot experiments to determine the limits of endurance of different farm crops for certain injurious substances, Part I (Wheat)" by F. B. GUTHRIE, F.I.C., F.C.S., and R. HELMS.

The authors describe experiments to test the effect upon the growth of the wheat-plant of the following substances occasionally found in the soil and in manures, and which are known when present in excessive quantities to act as plant poisons. *Sodium chloride* and *Sodium carbonate* which are present in many of the artesian bore-waters used for irrigating; *Ammonium sulphocyanide* which has been found in impure samples of ammonium sulphate; *Sodium chlorate*, occasionally present in sodium nitrate, and *Arsenious oxide* which may be present in superphosphate which has been manufactured with acid derived from sulphur or pyrites containing arsenic. The experiments were carried

out in cylindrical galvanized iron culture pots of familiar construction, and were located, with the kind permission of Mr. J. H. Maiden, in the Botanic Gardens. Details of the soil and manures employed, and of the appearance at different stages of the plants treated with varying proportions of the substances under examination were supplied. The following table summarizes the principal results obtained.

Effect upon germination and subsequent growth of wheat of different percentages of injurious substance in the soil.

	Germination affected.	Germination prevented.	Growth affected.	Growth prevented.
NaCl	·05	·20	·05 to ·15 (recovered)	·20
N_2CO_3	·30	·5 to 1·0	·10	·40
NH_4CNS	·005	·01	·001	·005
$NaClO_3$	above ·01	·05	·001	·003
As_2O_3	·05	0·50	·05	·10

Remarks were made by Mr. Maiden. The authors replied.

EXHIBITS.

1. Specimens of Permo-Carboniferous Bryozoa from Pokolbin and Black Head, consisting of *Stenopora Tasmaniensis*, *S. crinata*, *S. ? informis*, *Fenestella ? internata*, *Protoretepora ampla*, Polypora and Polyzoal limestone, exhibited by Mr. C. A. Süssmilch.

2. Stereoscopic views, showing erosion at various parts of the Hunter River to illustrate his remarks in the discussion on Mr. Maiden's paper, were exhibited by His Honor Judge Docker.

3. Blackfellows' Bread, *Polyporus Mylittæ*, C. and M. (*a*) Section in fructification; (*b*) Section developing the mycelium, exhibited by Mr. R. T. Baker, F.L.S.

ABSTRACT OF PROCEEDINGS, NOVEMBER 5, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 5th, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Thirty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. R. T. Baker and T. F. Furber were appointed Scrutineers, and Mr. C. O. Burge, deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—

Arnott, John Maclean, Manufacturer, Strathfield.

Jones, Henry Llewellyn, Assoc. M. Am. Soc. C. E., Civil Engineer, Mutual Life Building of New York.

The certificates of two candidates were read for the third time, and of one for the second time.

The President announced that the fifth and last Science Lecture for the present Session would be delivered on the 27th instant by Professor W. H. WARREN, Wh. Sc., M. Inst. C.E.' on "The Art of the Bridge-Builder."

Also that the Conversazione would be held in the Great Hall of the University on Friday, December 5th.

He also announced the death of Mr. James Comrie of Kurrajong Heights, one of the oldest members of the Society having been elected in 1856.

Twenty-five volumes, 168 parts, 7 reports, 3 pamphlets, and 2 atlases of meteorological charts, total 205 received as donations since the last meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "New South Wales Meteorites," by Prof. LIVERSIDGE, M.A., LL.D., F.R.S.

Prof. Liversidge read a paper upon certain meteorites found in New South Wales. *Barratta Meteorites*, Nos. 2 and 3—The first meteorite from this locality was examined by the author in 1872; these later ones were received by Mr. Russell, the Government Astronomer in 1889 from Mr. Kilpatrick, who had found them on the Barratta Station near the place where the first one was discovered. No. 2 weighed 31½ lbs, and No. 3 48 lbs, they both resemble the first one found very closely in appearance, specific gravity etc. No. 2 has on analysis been found to resemble No. 1 also in chemical composition, it is essentially a mixture of enstatite, olivine, etc., with about 6% of nickeliferous iron. No. 3 has not yet been analysed.

Gilgoin Meteorites, Nos. 1 and 2—These were given in 1889, to Mr. Russell, Government Astronomer, by Mr. J. A. Yeomans of Gilgoin Station, which is about 40 miles E.S.E. of Brewarrina and 516 miles N.W. of Sydney. The weight of No. 1 was 67½ lbs. and its sp. gr. 3·857. They are both much fissured and weathered. No. 2 weighed 74 lbs and has a sp. gr. of 3·757. No. 1 has been found on analysis to resemble the Barratta meteorites, but to contain more lime and alumina, and less iron and magnesia and about 14% of nickeliferous iron. No. 2 has not yet been analysed.

Boogaldi (Bugoldi) Meteorite—An account of this meteorite was given by Mr. R. T. Baker about two years ago, it has since been analysed, the principal constituents are iron 91·135, nickel 8·636, cobalt ·065, and phosphorus ·17.

2. "Forests considered in their relation to rainfall and the conservation of moisture," by J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

The following synopsis shows the method of treatment of this subject which is of considerable importance to us in New South Wales.

SYNOPSIS.

I. Introductory.

II. The Historical Method.
  - *a.* General observations.
  - *b.* The case "Forest destruction *does* diminish the rainfall."
  - *c.* The case "Forest destructiou *does not* diminish the rainfall.

III. The vastness of rainfall conditions.

IV. Clouds may strike against tress and deposit moisture.

V. Not merely a question of large trees.

VI. Rainfall Measurements in forests and open country.

VII. Physiological action of trees—transpiration.

VIII. Some uses of forests:
  - *a.* To temper floods.
  - *b.* To conserve springs and to aid in the more even distribution of terrestrial waters.
  - *c.* To prevent evaporation of water.
  - *d.* To give shelter to stock, crops, etc.
  - *e.* The leaves of forest trees etc., afford manure and mulch.

I bring before you the subject which is often conventionally known under the title of "Forests and Rainfall," and in regard to which it may be fairly said that there still exists, in New South Wales at least, a considerable amount of misapprehension. Even the clear cut statements of Mr. Russell, our Government Astronomer, that forests do not increase rainfall, have failed to carry conviction to some people, for the reason, I take it, that the broader subject of the effect of vegetation on the *conservation* of moisture has not been fully considered in some of the public discussions that have taken place. The term "Forests and Rainfall" has been adopted by many writers because of its compactness, but if its use becomes misleading then it should be amplified. We want to carefully separate two issues.

1. The effect of forests and other vegetation in increasing the rainfall.
2. The effects of the same in conserving moisture.

I do not approach the subject with any but the most elementary meteorological knowledge, but I have had much experience of Australian forestry. Taking an extensive territory, it appears to be indisputably proved that forests do not increase rainfall; it is fully as well proved that they conserve the rain that falls, and therefore every effort should be made to save them from unnecessary destruction. The historical method in regard to the treatment of the "Forests and Rainfall" question is then dealt with, and it is shown how defective is the evidence usually adduced and that it must give way to the scientific method, which relies on observation and experiment. The author deals with trees on the water courses in the catchment area of the Sydney Water Supply and discusses the question of the transpiration of their leaves. He concludes, "I now submit the whole subject to the consideration of members of the Society. The matter of forest meteorology and the questions that crop out of it present many puzzling problems to us in Australia, and some of them have as yet baffled the meteorologists of long settled countries. A proper understanding of the principles which underlie the relations of forests and moisture is of special interest to us in two special ways, first as regards the water supply of a large city (Sydney), and secondly as regards the distribution and conservation of moisture over the whole of the State. Reasonable expenditure for research would be justifiable if we could be thereby placed in a position to deal less empirically with the rainfall we receive, and to know how to conserve it more wisely than we do at present. A certain quantity of rain falls upon New South Wales; do we take care that it will do us most good and remain with us, benefitting us, as long as possible? Many public questions that loom large in in the public eye should really claim less of our attention than this."

A discussion ensued in which the following gentlemen took part:—Messrs. H. C. Russell, P. N. Trebeck, R. T. Baker, C. A. Benbow, Professor T. W. E. David and James Taylor. Mr. Maiden replied.

The following is an abstract of the fourth Science Lecture of the present Session, delivered on the 23rd October, by Professor W. A. HASWELL, M.A., F.R.S., on "Biology and and Every-Day Life."

After describing biology as not a single science, but a group of sciences, the common feature of which is that they deal with objects which are, or have been, endowed with life, the lecturer proceeded to discuss the nature of life, and to deal with the question:—Are living things to be regarded as automata? In doing so he gave an account of protoplasm—the physical basis of life—of the cell—the unit of organisation in both plants and animals—and showed how in plants and animals consisting only of a single cell, as well as in the individual cells of higher forms, complex processes are carried on in the absence of visible machinery. He pointed out further that in the development of a plant or animal from a germ or ovum, in which no structure is to be detected, we have further and still more remarkable results of a complicated nature attained without the presence of any mechanism capable of being detected by the highest powers of the microscope—the structureless germ containing within itself, not actually, but potentially, all the characteristics of the mature plant or animal. The phenomenon of the regeneration of lost parts was also shown to be difficult of interpretation as the outcome of known chemical and physical forces. After a discussion of the theories of pre-formation and epigenesis, the lecturer concluded this part of his address with the words—"If this result is attained by chemical and physical processes, let us at all events avoid committing ourselves to glib

statements about "the same chemical and physical processes that we see in action in the non-living world." There are no chemical and physical processes known that enable us to explain such vital phenomena as those to which I have referred: and it is best for the interests of truth and for the future progress of science that we should boldly face the necessity of admitting our ignorance." The rest of the lecture was occupied with the more utilitarian aspects of biology—most of the time being given to the connection between biology and the development of fisheries. The more generally recognised importance in this connection, and in relation to research in pure biology, of Biological Stations was pointed out; and an account was given of some of the leading institutions of this kind in Europe and America, and the work that they had done and were doing—stress being laid on the need for the establishment of such stations in Australia from a purely scientific as well as an economic point of view.

ABSTRACT OF PROCEEDINGS, DECEMBER 3, 1902.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 3rd, 1902.

Prof. WARREN, M. Inst. C.E., Wh. Sc., President, in the Chair.

Forty-four members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. G. H. Halligan and J. L. C. Rae were appointed Scrutineers, and Mr. H. A. Lenehan deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

Ames, William (late R.N.) M. Inst. N.A., North Sydney.

The certificate of one candidate was read for the third time, and of one for the first time.

Messrs. David Fell, Member of the Corporation of Accountants of Australia, and T. T. Peterson, Associate Sydney Institute of Public Accountants, were appointed Auditors for the current year.

The President announced that the Conversazione would be held in the Great Hall of the University on Friday, December 5th.

Eleven volumes, 132 parts, 5 reports, and 4 pamphlets, total 152, received as donations since the last meeting were laid upon the table and acknowledged.

The following letter was read:—

State Government House,
Sydney, 27th November. 1902.

Dear Sir,—In reply to your letter of 25th instant I am directed by His Excellency to inform you that he is pleased to accept the position of Vice-Patron of the Royal Society of New South Wales.

Yours faithfully,
ROBERTSON CLARK,
Acting Private Secretary.

The Hon. Secretary, Royal Society of N. S. Wales.

THE FOLLOWING PAPERS WERE READ:

1. "On the occurrence of an important Geological Fault at Kurrajong Heights, Blue Mountains," by Professor T. W. EDGEWORTH DAVID, B.A., F.G.S., F.R.S.

The fault described herein was first observed by the author in company with Mr. G. W. Card, A.R.S.M., at the "Cut Rocks," just west of "Northfield," the residence of the late James Comrie, at Kurrajong Heights. That such a fault probably existed seemed clear from the general configuration of the Blue Mountains, seen from the direc-

tion of Woodford in an easterly and north-easterly direction. Such a view shows that the even easterly slope of the plateau is interrupted by abruptly rising ground just west of Kurrajong Heights. This sudden rise in the plateau extends for a considerable distance to the north and south of that locality. Traced in a southerly direction across the Grose Valley to Glenbrook Railway Station, the fault to which this Westerly escarpment is due, almost, if not altogether, dies out passing into a gentle westerly fold, which at Glenbrook does not appear to have been accompanied by shearing. To the east of Glenbrook Railway Station is the well known steep *easterly* monocline, referred to by the late Government Geologist, Mr. C. S. Wilkinson, which there forms the Eastern escarpment of the Blue Mountains, known as Lapstone Hill. Traced northerly from Lapstone Hill the moncline crosses Grose Valley and forms the eastern slope of Kurrajong Heights. The top of the monocline at Kurrajong Heights is over 1900 feet above sea level, and the top of the fold is about 1100 feet above the bottom of the fold, whereas at Glenbrook the top of the fold is only about 600 feet above the bottom of the fold. This seems to show that the movement of the earth's crust has been more extensive at the Kurrajong than at Glenbrook. This may account for the fact that the monocline at the Kurrajong is bounded westwards by an abrupt fault, whereas at Glenbrook the line of disturbance takes the form of a gentle fold facing the west. The Kurrajong fault has a throw to the west of 300 feet. The fault plane though somewhat eroded still forms a steep and very conspicuous escarpment. The Wianamatta shales on the downthrow side of the fault extend for a considerable distance towards Mount Tomah along the watershed separating the Grose Valley from the Colo Valley, and known as Bell's Line. The effect of this fault in displacing

the coal-measures on either side of it will obviously claim the serious attention of those who in the future have charge of coal mines in that portion of our coalfields.

Remarks were made by Mr. C. A. Benbow and Mr. J. C. L. Rae.

2. "Investigations in regard to the comparative strength and elasticity of Portland cement mortar and concrete when reinforced with steel rods and when not reinforced," by W. H. WARREN, M. Inst. C.E., M. Am Soc. C E., Challis Professor of Engineering, University of Sydney.

The paper described experiments on various mortars and concrete in tension and compression, also when subjected to bending stresses. The extensions, shortenings and deflections were accurately determined by means of Marten's mirror apparatus and sector deflectometers, and the results plotted gave characteristic diagrams. *Tension*—The extensions of the specimens subjected to direct tension when reinforced with steel rods were considerably less than occurred in similar specimens not reinforced, the stress-strain diagrams plotted from the observations taken were all convex to the stress axis, but the curve was much flatter for the reinforced specimens. The coefficient of elasticity calculated from the stresses and elongations decreased as the stress was increased. *Compression*—The compression tests were made on prisms 12 inches by 6 inches by 6 inches, and the coefficient of elasticity calculated as in the tension tests. The curves representing the stresses and shortenings of the prisms, were much flatter than in the tension tests, and the coefficient of elasticity greater. The coefficient of elasticity increases with the age and richness of the mixture. *Transverse tests*—The transverse tests consisted of experiments with beams reinforced on the tension side with steel rods, compared with similar beams not reinforced. Experiments were also made on

beams of the same width and containing the same area of bars on the tension side, but varying in depth. In all cases the reinforced beams were from $5\frac{1}{2}$ to 10 times stronger than the plain beam, and the deflections of the beams before fracture were enormously greater in the reinforced beams. The paper consists of eight tables of results and 20 diagrams.

A discussion ensued in which the following gentlemen took part, Messrs. Henry Deane, L. Whitfeld, Prof. David, Messrs. C. O. Burge, F. Gummow, G. R. Cowdery, and C. A. Benbow. Prof. Warren replied.

3. "The fallacy of assuming that a wet year in England will be followed by a wet year in Australia," by H. C. Russell, B.A., C.M.G., F.R.S.

It is a widespread idea that if abundant rain falls in England there will be an abundant rainfall in Australia in the following year. By means of a diagram showing the rainfall in England and in Sydney for a number of years in succession, it is shown that as a matter of fact this seldom occurs. Amongst the more striking examples shown by the diagram are the following. In the years 1880 – 85 rain was very abundant in England, and during the whole of that period we were suffering from a very severe drought. Again the years 1894 – 1900 show abundance of rain in England, and Australia during these years has been suffering a severe drought.

A question was asked by Mr. D. Carment.

4. "On the presence of platinum and iridium metals in Meteorites," by Professor Liversidge, LL.D., F.R.S.

At the September meeting of the Society the author described the occurrence of gold in meteorites; in certain cases the gold is accompanied by one or more of the platinum and iridium metals. The Boogaldi meteorite

contains both gold and one or more of the platinum metals; these metals do not appear to be uniformly diffused through the meteorite, for some parts apparently contain a much larger proportion than others. The meteoric iron was dissolved in hydrochloric acid, the usual black carbonaceous residue was then ignited and afterwards ground in an agate mortar. On washing off the lighter powder the metals are seen as lustrous yellow and silvery spangles; by means of a needle these can for the most part be picked up and separated. The first few white metallic spangles obtained were insoluble in a mixture of nitric acid and hydrochloric acids when warmed and evaporated to dryness on a microscope slide (the tests were at first applied under the microscope) and it looked as if the white spangles consisted solely of iridium metals, insoluble in nitrohydrochloric acid, but afterwards it was found that another portion of the meteorite yielded a larger quantity of them and this treated with a larger volume of aqua regia dissolved. Both gold and platinum were separated from the solution by the usual wet methods; iridium and other metals of this group are probably present. The amount of the platinum metals in the Boogaldi meteorite is comparatively large, being at the rate of several ounces per ton; details will be found in the paper.

Remarks were made by Mr. J. H. Maiden and Dr. Walter Spencer.

5. "Is Eucalyptus variable?" by J. H. MAIDEN, Director, Botanic Gardens, Sydney; Government Botanist of New South Wales.

SYNOPSIS:—

I. The variability of characters considered seriatim.

II. Has variation in Eucalyptus now ceased?

III. Some studies in variation.

IV. Mannas, Kinos, Oils, etc., are non-essential or adaptive characters and examination of them must be simply looked upon as aids to diagnosis.

V. Botanical classification for purposes of nomenclature of genera, species and varieties is based on morphological characters.

Under (I.) the author takes the following characters seriatim, and shows that they all vary:—Habit, bark, timber, exudations, petiole, leaf—*a.* suckers, *b.* cotyledon leaves, *c.* venation, *d.* young stems, *e.* essential oil, *f.* stomata—galls, inflorescence, anthers, pollen-grains, calyx, fruit. The author concludes with the following remarks: "It seems strange to me that with evidence (as I contend), simply inexhaustible, of variation in Eucalyptus, both as regards spontaneous and cultivated plants, where it is sometimes necessary (I believe) to name a plant with the qualifying note that another botanist may have good grounds for placing it in an allied species, this doctrine of variation apparently does not command universal acceptance. It seems to me that the "non-variation" theory runs counter to some of the most generally accepted sets of practical observations on which the doctrine of evolution of species is based, and there is just a little danger of what Darwin terms "arguing in a circle" in presenting the observations that are interpreted to destroy the dogma which many of us consider as built upon unassailable facts."

Remarks were made by Mr. R. T. Baker, Dr. Walter Spencer, Mr. Henry G. Smith, and Mr. C. A. Benbow.

The following is an abstract of the fifth Science Lecture of the present Session, delivered on the 27th November, by W. H. WARREN, Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E., Challis Professor of Engineering, President of the Royal Society.

The lecturer stated that the most significant feature of the Nineteenth Century is to be found, not so much in its ideas, as in its material attainment. Beyond doubt the Nineteenth Century carries the stamp of Engineering, and it will probably be the best known to the future historian as the Century of Engineering. It is now clearly established

that engineering, and above all the material indispensable to engineering work, viz., iron, has supplied the Nineteenth Century with the material foundation for its progress. In ancient times iron was mainly prized on account of its manifold applications in warfare. It was rarely met with in architecture and bridge building until the close of the Eighteenth Century. At the beginning of the Sixteenth Century the idea of casting bridges, roofs and floors entirely of bell-metal appears in the writings of the Venetian engineer, Faustus Verantius of Dalmatia. Lantern slides were shown illustrating Verantius' proposals for an arched bridge, also for a suspension bridge. The first real iron bridge ever built was of cast iron over the river Severn at Coalbrookdale in 1776, which stood until this year, when it collapsed. Many bridges were cast in England after this model during the last twenty years of the Eighteenth Century. The use of cast iron as a constructive material was limited by its comparatively small resistance to a tensile or pulling stress, and in the second quarter of the Nineteenth Century wrought iron began its upward career, competing successfully with wood and stone. The systematic testing of the materials of construction was commenced about this time, with a view to determine the behaviour of materials when subjected to stresses of various kinds, and in the meantime the incessant reciprocal action between the development of railways and the manufacture of iron urged forward further facilities for bulk production, as well as the attainment of a higher standard of excellence. In 1851 Krupp of Essen, Germany, first demonstrated how to make crucible steel in large quantities, and in 1855 Henry Bessemer succeeded in producing ingot steel in bulk without the necessity of using either crucible or hearth. These inventions were followed by those of Martin and Frederick Siemens, and resulted in the pro-

duction of Siemens-Martin steel; afterwards Thomas succeeded in producing basic steel. Thus the art of the bridge builder was aided by the scientific and practical work of the metallurgist and engineer; although for many thousands of years iron was only obtainable immediately from the ore, afterwards the metal produced on the hearth took the lead for 400 years. Compared with this the eighty years during which wrought iron ruled supreme, and the short period since it was superseded in its turn, lapse into insignificance. Who will assert how long mild steel in its present form will keep its place? Already aluminium and nickel are being added to it for different purposes, and no doubt further surprises await us in the course of the present century. The lecturer then dealt with the history of girder systems and the theory of bridges, illustrating his remarks by numerous lantern slides of well known bridges, of the plate web, lattice and bowstring girder type, as well as truss-bridges constructed in various parts of the world. The art of the bridge builder in its earlier stages depended more upon judgment than exact theory, and it was not until the investigations of such men as Clapeyron, Castigliano, Mohr and De Saint Venant had been studied that both in its theoretical and practical aspect the art became most precise and exact in every particular. Robert Stephenson, however, actually built the Menai Bridge eight years before De Saint Venant published his theory. Dealing with arches and suspension bridges, the lecturer stated: "that the arch is more economical than the most economical truss, where the site and local conditions are favourable for the construction of suitable abutments at moderate cost." This fact was illustrated by comparing the arch with the bowstring girder. The suspension bridge is the inverted form of the arch bridge, in which the tension in the suspended rib or cables correspond with the compres-

sion in the arch rib. In either case, if the rib is loaded in any way whatever, the correct form, in order that it may sustain the load without bending, is the equilibrium curve or polygon for the loading in question. A large and comprehensive series of slides were shown illustrating the construction of various types of arch and suspension bridges, some of which are as beautiful architecturally as they are sound in construction, as for instance, many of the bridges over the Seine in Paris. The defects in Robling's system were briefly explained, and also the theory of the modern stiffened suspension bridge, consisting of steel cables and steel stiffening girders. As an example of the principle of the cantilever bridge a slide was shown in which the Forth Bridge was compared with two men supporting a third in a special manner. A few examples were shown of movable bridges worked by hand, steam, hydraulic and electrical power. In conclusion the lecturer stated that the art of the bridge builder is well illustrated by the various designs which have been submitted for the proposed Sydney Harbour Bridge. The conditions laid down by the Advisory Board were briefly explained, five of the best designs were thrown upon the screen, and the special merits and features of each were critically discussed.

CONVERSAZIONE.

A Conversazione was held in the Great Hall of the University, on Friday, 5th December, at 8·30 p.m., under the management of a Committee composed of the Officers and Council of the Society. The Hall and approaches were tastefully decorated with ferns, palms, and rare pot plants.

The University grounds were illuminated with electric light thus lighting the way for the guests to visit the various Laboratories which were thrown open. The guests numbered about 450. Unfortunately His Excellency the State Governor was absent from town, but His Excellency

Vice-Admiral Sir Lewis Beaumont and Lady Beaumont were present, also the Lord Mayor, Lady Mayoress, and various other distinguished guests.

EXHIBITS.

Mr. C. A. BENBOW, Pictures, etc.

Mr. C. O. BURGE, Old Books.

Mr. J. H. CARDEW, Photographs.

Mr. S. CORNWELL, Microscope and Spectroscope.

Mr. J. V. DE COQUE, Carved Maori Walking Stick.

GEOLOGICAL SURVEY OF NEW SOUTH WALES, Meteorites and Mineral Specimens.

DIRECTOR OF THE BOTANIC GARDENS, Collection of Pot Plants.

Mr. G. H. HALLIGAN, Working Model of Tide Gauge.

Prof. HASWELL, Specimens from Biological Laboratory.

Mr. R. HELMS, Collection of Coins.

Prof. LIVERSIDGE, Meteorites and Gold and Platinum from Meteorites.

MEDICAL SCHOOL, UNIVERSITY, Miscellaneous.

MINING AND GEOLOGICAL MUSEUM, Fossil Skeleton.

Dr. QUAIFE, Fluorescence and Polarization Experiments.

Mr. W. S. DE LISLE ROBERTS. Cement Testing Machine, and Photographs of Cements.

Mr. RUSSELL, Meteorite and Scientific Apparatus.

Mr. NORMAN SELFE, Pictures of Old Sydney.

Dr. WALTER SPENCER, Oriental Art Objects and Old Books.

Mr. C. A. SUSSMILCH, Collection of Fossil Leaves.

Mr. J. TAYLOR, Specimen of Molybdenite.

Mr. R. TEECE, Calculating and Adding Machines.

TECHNOLOGICAL MUSEUM, Reproduction of Hildesheim Treasure. Case of Models of Fungi.

UNIVERSITY OF SYDNEY, Illuminated Addresses received at its Jubilee.

Senator J. T. WALKER, Old Documents, Daguerrotype and Engraving.

Mr. E. W. WARREN, Electrical and other Apparatus.

The Chemical, Engineering, Geological, Metallurgical, and Physical Laboratories were open during the evening.

At 9 p.m. Professor DAVID delivered a short lecture on "Volcanoes and Earthquakes," illustrated with lantern views, in the Lecture Theatre of the Geological Department. A working model of a geyser was in operation in the same place.

At 9·30 p.m., Professor WARREN gave a demonstration on the "Testing of Material used in Construction" in the Engineering Laboratory.

The following donations were laid upon the table and acknowledged:—

TRANSACTIONS, JOURNALS, REPORTS, &c.

(The Names of the Donors are in *Italics.*)

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PROCEEDINGS OF SECTIONS.

PROCEEDINGS OF THE SECTIONS

(IN ABSTRACT.)

SECTION OF ECONOMIC SCIENCE.

The opening meeting of the second session of the Economic Section of the Royal Society took place on 28th May, 1902, when an address was delivered by RICHARD TEECE, Esq. F.I.A., as Chairman of the Section.

At the monthly meetings papers were read as follows:—

Date.	Author.	Subject.
3 July,	Mr. R. L. NASH,	"Bank notes *v.* Government notes.
30 July,	,, H. B. BIGNOLD,	"Imperial Defence."
27 Aug.,	,, A. DUCKWORTH,	"The Timber Industry and Forests of New South Wales."
24 Sept.,	,, W. PEARSE,	"The overproduction fallacy."
26 Nov.,	,, JOHN PLUMMER,	"Some recent co-operative developments."

These papers were discussed by the members of the Section at the meetings subsequent to their being read.

The following are the officers of the section :—Committee —Messrs. J. PALMER, D. CARMENT, F.I.A., J. HENDERSON, F. J. THOMAS, A. HALLORAN, LL.B. Past-Chairman, Mr. RICHARD TEECE; and Hon. Sec. Mr. A. DUCKWORTH.

ENGINEERING SECTION.

During the Session five ordinary monthly meetings were held.

Meeting held May 21st, 1902.

Mr. H. G. MCKINNEY, in the Chair. Present twenty-four members and visitors. The Chairman delivered the annual address, his subject being "A comparison between Government Initiative and Private Enterprise in the construction of Engineering Works in various countries."

At the suggestion of the Chairman, the subject of the address was then discussed, the following members taking part:—Messrs. BURGE, CARDEW, MANSFIELD, DEANE, ROSS, HOUGHTON, BIRKS, COWDERY, HENNESSY, BARRACLOUGH, and Dr. QUAIFE.

Meeting held 18th June, 1902.

Present, Mr. H. G. McKINNEY (in the Chair) and twelve members.

Mr. CARDEW read a paper entitled "The Importance of Federal Hydrography," which was discussed by Professor WARREN, and Messrs. BURGE, HALLIGAN, SHEPHERD, and the Chairman.

Meeting held 20th August, 1902.

Present, Mr. H. G. McKINNEY (in the Chair) and fourteen members and visitors.

The Chairman made sympathetic reference to the very serious and prolonged illness of Mr. H. H. DARE, Joint Hon. Secretary of the Section.

Mr. BURGE read a paper entitled "Recent developments in high-speed railway construction and working," the discussion thereon being adjourned.

The discussion on Mr. Cardew's paper was continued by Messrs. LENEHAN, DEANE, BURGE, BARRACLOUGH, PEAKE, Dr. QUAIFE, and the Chairman, and replied to by the author.

Meeting held 15th October, 1902.

Present, Mr. H. G. McKINNEY, (in the Chair) and eighteen members.

Mr. BURGE'S paper was discussed by Messrs. SELFE, HOUGHTON, SHAW, CARDEW, BARRACLOUGH, COWDERY, BIRKS, Prof. WARREN, and the Chairman.

The members present then discussed very fully the question of reorganizing the Engineering Section with a

view of increasing its usefulness and efficiency. It was finally decided that for the customary monthly meeting, there be substituted two or three "Sessions" to be held at intervals of about three months; the necessary arrangements to be made by the Committee.

Meeting held 17th December, 1902.

Present, Mr. H. G. McKinney (in the Chair) and thirty-three members and visitors.

The Committee for the ensuing year was elected as follows:—Chairman, S. H. Barraclough, M.M.E., Assoc. M. Inst. C.E. Hon. Secretaries: H. H. Dare, M.E., Assoc. M. Inst. C.E., and J. H. Cardew, Assoc. M. Inst. C.E. Committee: C. O. Burge, M. Inst. C.E., G. R. Cowdery, Assoc. M. Inst. C.E., J. Davis, M. Inst. C.E., Henry Deane, M.A., M. Inst. C.E., Herbert E. Ross, P. W. Shaw, Assoc. M. Inst. C.E., J. Taylor, B.Sc., A.R.S.M., Prof. W. H. Warren, M. Inst. C.E., M. Am. Soc. C.E. Past Chairmen: Norman Selfe, M. Inst C.E., M.I. Mech. E., J. M. Smail, M. Inst. C.E., H. G. McKinney, M.E., M. Inst. C.E.

Mr. Houghton then read a description of a Three-rail Tramway suitable for very sharp curves, which he had recently built.

Mr. Barraclough, then delivered an address illustrated by lantern slides, entitled:—"Typical National Industries: A sketch of Krupp's Steel Works at Essen; The Carborundum Company's Works at Niagara; Parsons' Steam-turbine Works at Newcastle-on-Tyne."

Votes of thanks to the Chairman and Officers concluded the meeting.

ANNUAL ADDRESS.

By H. G. McKinney, M.E., M. Inst. C.E.,

On a comparison between Government Initiative and Private Enterprise in the Construction of Engineering Works in various Countries.

[Delivered to the Engineering Section of the Royal Society of N. S. Wales, May 21, 1902.]

Gentlemen,—I have to thank you for the honour you have conferred on me by electing me as your Chairman for the current year. In past years, my duties frequently took me away from Sydney for considerable periods, and owing to this I have been but an irregular attendant at the meetings of this Society and of the Engineering Section. Your generosity in overlooking this enhances the compliment to me and adds to my obligations to you.

My predecessors have, in their opening addresses, given you a series of able and instructive statements of the progress of engineering science and engineering works, the address being sometimes confined mainly to one branch of the profession. I propose to depart from the usual course, and to describe in outline the procedure adopted in various parts of the world, and particularly in the British dominions and the United States, in the initiation and management of large engineering projects.

It is scarcely necessary to state that the subject is a very large one, and one regarding which volumes might be written; so that it is impossible for me to do more than touch on the salient features of the question, and to refer to some of the most instructive illustrations. It is obvious that the systems which are most conducive to the developing of engineering enterprise, or for fostering (to quote the

words of the Charter of the Institution of Civil Engineers) "the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade," must vary widely in different countries inhabited by people differing in their traditions and in their stages of advancement in civilization. The two extremes in the attitude of the people in regard to the development of a country by the construction of engineering works are fairly illustrated by the cases of India and the United States. In the former country the people have no idea of any other course than to await the action of a paternal and benevolent Government to supply them with roads, railways, and irrigation works; while the people of the United States are decidedly opposed to what they aptly term "paternalism," and simply want the Government to leave them alone and give them a free hand. It is a great mistake to suppose that a system which is best for one country, either is or will be the best for another; but this fact is often overlooked, as for instance by those well-meaning people in England who are continually aiming at foisting on India institutions and procedure with which they are familiar, but which the people of India neither want nor appreciate.

In the United Kingdom it may be broadly stated that all public works of importance, except those for the water supply and sewerage of towns, are initiated, constructed, and managed by private enterprise. The facilities for the initiation of extensive works have been greatly added to by the Ordnance Survey which was carried out by the Government, as the information supplied in the Ordnance maps is in such detail that preliminary surveys for railways and other large works are unnecessary. This is one of the many ways in which the value of a minutely accurate national survey becomes apparent to the most ordinary

mind. When it is proposed to construct a railway or other large work, the project has to be submitted to Parliament and a special bill has to be introduced and carried before the work can be proceeded with. As a general rule, the only opposition which such a bill is likely to meet is that from parties who consider that their rights are prejudicially interfered with. The company which brings forward the project undertakes all risks, and the people of the district directly affected are naturally in favour of the expenditure of a large amount of money in their neighbourhood and of the advantages which the proposed work will afford; so that unless there is likely to be serious interference with existing rights, a bill for a useful work is passed as a matter of course. In short, the only objections which would be allowed to stand in the way would be objections of a purely practical and non-political character.

So far as railways in the United Kingdom are concerned, the only cases, so far as I have been able to ascertain, in which the Government has taken any direct part in promoting the construction of new lines, have been in Ireland in recent years. The necessity for light branch lines extending into some of the poorer and more remote districts was observed by Mr. Balfour when Chief Secretary, and the result was the passing of an Act of Parliament under which the Government guarantees part of the interest on the outlay while the landowners guarantee the balance. The branch railways constructed under these conditions have proved a great boon; but it is to be noted that the Government did not saddle itself with either their construction or management.

As might naturally be expected, municipal institutions in Great Britain and Ireland have, from long experience, reached a high scale of efficiency in their management. The construction of works for water supply, for sewerage,

in some cases for the supply of gas or of electric light, and even the construction of tramways, has been carried out by the local authorities of the cities and towns, and there is a healthy emulation to keep the management of such works efficient and up to date. All this is done without any assistance or any interference from the Government. Business is, in fact, carried on in regard to both the construction and management of these works as it would be done by large private concerns, and the officers who are directly responsible, are chosen with the greatest care and remunerated in proportion to their duties and responsibilities. The public roads throughout the United Kingdom are under the management of local authorities; but while in England and Scotland these authorities appoint all their own officers, in Ireland the County Surveyors, as they are termed, or the County Engineers as they should be described, are appointed by the Government under a system of public competitive examination.

The construction of navigation canals has been carried out by private or local enterprise, and the management of these canals and of river conservancy is left either to private companies or to Boards or Trusts. It is necessary to remark that in the United Kingdom the whole question of river conservancy is in an unsatisfactory state through the want of suitable legislation. This is a subject which I referred to at some length in a paper presented to this Society in 1887, and I understand that little, if anything, has been done by way of remedy since then.

To sum up the position of affairs in the United Kingdom so far as the construction of large engineering works is concerned, we find that works of all kinds are constructed and managed by private enterprise, or by boards, councils, or trusts, and that the functions of the Government in regard to all such works are simply to investigate whether

they are consistent with public interests and private rights and if so to afford. the necessary authority for their construction and management.

In the case of India it was recognised from the outset that all public works of importance should be either actually or practically under Government control. The construction of roads was early taken in hand by the Government, and it is safe to state that the grand trunk roads are not excelled by any in the world. Not long ago, a touring cyclist stated from his own experience that in Upper India he could go for a thousand miles along a road any part of which is better than the best road in England. In the early days of railway construction, the main trunk lines were constructed by companies, the Government guaranteeing a specified minimum interest on the outlay, but stipulating that when the net return exceeded this rate, the Government would be entitled to half the excess. This system was probably the best that could have been adopted at the time, and on the whole it proved very beneficial to the country and fairly satisfactory to all parties concerned. In the course of time, owing to the necessity for frontier railways for strategic purposes, as well as other grounds, it was deemed advisable for the Government to take up the construction and management of railway lines, and as a rule this policy is now adopted. The Government of India, however, takes a very broad view of the question. There are lines which have been constructed and are managed by companies, others which have been constructed and are managed by the Government, and some which were constructed by the Government and are managed by companies.

All the great irrigation works of India—the finest and the most extensive irrigation works in the world—are purely Government undertakings. The political and social con-

ditions of the country render it necessary that this should be so; but these conditions aid in the adoption of the best schemes and in the attainment of the highest efficiency in their management. As the Hon. Alfred Deakin states in his excellent work "Irrigated India," "The advantages of a despotic rule are exhibited in such cases as these, where the officers of the Department are perfectly free to choose the best scheme possible, and to execute it without regard to the individual wishes or interests of their constituents. In the colonies these would be forced upon their attention at every step, and they would have to pay dearly for any encroachment, or imaginary encroachment upon them." This statement of the case is admirably put, and indicates clearly that the system which is undoubtedly the best for India would be likely to prove a failure if attempted in the self-governing colonies. In regard to the management of the irrigation works, Mr. Deakin aptly sums up the position in these words:—"Liberal as are the provisions under the Victorian Irrigation Act, and unparalleled colonially, except in South Australia, they are not nearly so favourable as are the conditions under which the Hindus obtain their water supply, and the money necessary to enable them to make the best use of it. This Asiatic despotism after all is kinder than any democracy has yet proved itself to be." In view of this generous treatment of the people who use the water, the direct as well as the indirect financial results speak volumes for the efficiency of the administration of the irrigation works. The direct return on the outlay is seldom so low as five per cent., that from a a number of the largest works varying from seven to ten per cent, while in some cases the net return is as high as twenty per cent.

From what has been stated it will be seen that so far as large engineering works affecting any considerable number

of people are concerned, the Government of India holds a monopoly. The only important exceptions are the guaranteed railways and the local works of some of the large towns.

Turning from India to Canada, we come to conditions in many respects resembling those of Australia. The various States which constitute the Dominion of Canada have their separate Governments, which deal with State questions, while the Dominion Parliament has powers closely corresponding to those of the Federal Parliament of Australia. While in the great extent of its territory, the nature of its Government, and the British origin of the great majority of its people, Canada bears close resemblance to Australia, there are two important points in which there is a marked contrast; namely the climate and the natural features of the country.

The earliest engineering works of first class importance in Canada were those for the improvement of inland navigation, and they from first to last have been dealt with by the Government. The enormous extent of the inland waterways, and their vital importance to both the internal and external trade of the country, classed their care and development as a national question in the highest sense of the term. In fact, for a long time the settlement of the country was confined almost entirely to districts possessed of water communication. When the construction of railways was taken in hand, the problem had soon to be solved as to what was the best system for carrying the railways through country that was either not taken up by settlers or that was settled only to a very limited extent. To induce companies to construct railways under such conditions, extensive grants of land and also of funds were made to them by the Dominion Government, as well as by the Governments of the States. In the case of the Canadian

Pacific Railway the area of land granted in this way was twenty-five millions of acres. This and other railways constructed under similar conditions, have had an excellent effect in promoting settlement; and the steady influx of population, the general prosperity and the absence of an unemployed class, all tend to indicate that the development of the country has proceeded on sound lines. The purely Government railways are only a small fraction of the total length.

No other country in the world has such a record as that of the United States, as regards the construction of large engineering works. The immense area of fertile land suitable for settlement, the great value and variety of its mineral resources, and the unsurpassed system of its natural inland waterways afforded the widest scope for engineering enterprise. The extent to which these resources have been developed is a monument of what can be done by a resourceful people to whom an enlightened Government has given a free hand. The railways of the United States, which have an aggregate length comparatively little short of the combined lengths of all the railways throughout the rest of the world, were constructed entirely by private enterprise. In many cases the lines were carried out under the land grant system—an arrangement which offers many advantages in a new country. When a company was authorised to construct a railway under this system through public lands, it was to the interest of that company that the line should pass through the best land available for settlement. The engineers, surveyors, and agents of such a company had thus to keep before them, not only questions bearing on the best grades, the minimum of engineering difficulties, and the minimum expense of construction, but also questions relating to the best quality of land for settlement and the best sites for future towns. It would be

difficult to estimate the saving in time, expense and trouble, which this arrangement secured to the settlers who rapidly followed the lines which such capable and interested pioneers marked out for them. To prevent the land grant companies from holding a monopoly of the land adjoining the railways, the Government retained alternate blocks, and in some cases it was specified that the Government should have the right of first sales. This system had an excellent effect in stimulating both railway construction and settlement; and judging by its results, it was certainly a remarkable success. The care and judgment which were exercised in the alignment of these railways prepared the way for the extremely low rates which the companies can afford to charge for freight. It is worthy of special note that the Government of India in carrying out the great irrigation works which had done so much for that country, had not a freer hand than these American Railway Companies when once they have obtained the necessary concessions. The railways in the United States have from first to last been carried out by private enterprise, and the part played by the Government has simply been to encourage this enterprise in every way that was reasonable and in accordance with the interests of the country. The policy in this respect has been practically identical with that adopted in the United Kingdom.

There is one important branch of engineering in the United States which is dealt with by the Government, and in connection with which distinguished service has been done by the United States Engineers, a body corresponding in military training and status to the Royal Engineers of the United Kingdom. The branch referred to is river conservancy, and the works carried out are chiefly for the improvement of navigation and the prevention of damage from floods. The reports of the United States Engineers

are a most valuable and instructive record of the construction of locks, weirs, wharves, and river training works in all parts of the States. By way of expressing my own indebtedness to these reports, I may mention that when I had the design of the Bourke Lock and Weir in hand, feeling dissatisfied with the common arrangement of working the Chanoine shutters by means of a tripping bar operated from one end of the weir, I searched every authority I could find for a record of the successful working of some more trustworthy and simpler method, and I found it in these reports. The success of the Pasqueau shoe for the shutter props of the movable weirs constructed by the United States Engineers on the Great Kanawha River in Virginia emboldened me to adopt that principle at Bourke. As regards the success of the shutter weir at Bourke, Colonel Home, R.E., C.S.I., who had risen through all the grades of the Irrigation Department of India till he reached the top as Inspector General, and who was familiar with all the types of weir used there informed me, in reply to a question on the subject, that in designing a weir in connection with the proposed Murrumbidgee Southern Canal, he did not think I could adopt a better style than that constructed at Bourke. The Pasqueau arrangement, so far as I could ascertain, had been used on only one weir in France, although it is the invention of a French engineer. The invention is a recent one, and its prompt adoption in the United States shows that the practice of the Government engineers there is thoroughly up to date.

The most recent addition to the duties of the United States engineers is the construction of reservoirs for the storage of flood waters so as to afford the means of extending the period and range of navigation on the upper parts of rivers.

Considering the immense extent and incalculable value of the inland navigation of the United States, as well as

the innumerable interests involved, it was only natural that the question should be regarded as one which should be dealt with by the Federal Government. With the exception of such purely military works as fortifications, the only large engineering works which are under the charge of the Government engineers are those for the improvement of navigation and particularly of inland navigation; but they have also charge of the preliminary surveys of the vast extent of country known as the Arid Region, including the taking of levels and locating the sites of reservoirs for irrigation purposes. An officer of the United States Engineers lately contributed an interesting article to one of the magazines, recommending that the construction of reservoirs for irrigation purposes as well as the locating of sites should be undertaken by the Federal Government; but no such step has been taken in this direction, nor does it seem likely that any will be taken.

Coming now to the irrigation works of the United States we find a record, like that of the railways, of almost unparalleled progress in which the Government has drawn the benefits arising from increase of settlement, production, and wealth, while it has incurred no outlay and no risk. In a few unimportant cases, municipal authorities have constructed irrigation works on a small scale; but as the Honorable Alfred Deakin states in his valuable Report on Irrigation in Western America, "All the irrigation works of Western America, with the exceptions above named have been constructed and maintained wholly and solely by private persons. Not only has the Government spent nothing upon them, but it has known nothing of them." This report was presented by Mr. Deakin in June, 1885, and since then the same system has been followed with the same vigour. In 1893, an International Irrigation Congress was held at Los Angeles in California, and repre-

sentatives from all the States in which irrigation is practiced were present. A point which was abundantly evident from the proceedings of this Congress was that not only had the Government given no assistance in the construction of irrigation works, but that the neglect to pass suitable legislation had seriously impeded irrigation enterprise. In 1885, Mr. Deakin when referring to the works which had then been carried out, wrote as follows:—"They have been constructed outside the law, extra legally, if not illegally. Even now only two States and one Territory have attempted to deal legislatively with any of the problems raised, and it is not claimed that in more than one of these has anything substantial been achieved." The legal position of the owners of extensive irrigation works in Western America was, in fact, as unsatisfactory as that of the owners of dams and pumps on the rivers and creeks of New South Wales before the passing of the Water Rights Act. Since the date of Mr. Deakin's report, a number of the States have adopted the principle of the State ownership of the rivers, which is the fundamental principle of our Water Rights Act, but this has not altered the policy adopted in the construction of irrigation works. In the proceedings of the Irrigation Congress referred to, such expressions as "We want no paternalism" were repeatedly used, and there appeared to be a general feeling that it was not right either to wish or expect that the Government would undertake any irrigation works in settled districts. The only direction in which any assistance was wanted was indicated in the desire that the Government should carry out preliminary surveys to determine the character and outline of the country, and that it should locate suitable sites for reservoirs, and conduct a system of river gauging. The case was very clearly put by one of the representatives of Kansas as follows:—"Let it be understood, however, that no friend of the Great Plains

country, who is conversant with the situation, either asks or expects the National Government to construct the irrigation systems necessary to the reclamation of the semi-arid lands. All that we ask of the Government is such legislation as is necessary, and a very moderate amount of experimenting and demonstration." The system under which irrigation in Western America has made such remarkable progress, has as its main features untrammelled private enterprise working with the consent and co-operation of the settlers. The spirit of self-reliance and enterprise of the people is aptly indicated by the quotation I have given from the speech of the representative of Kansas, and the results of that spirit are shown to the world in the millions of acres irrigated, and the thousands of car loads of produce which are sent away annually from land which, not many years ago, was regarded as almost valueless.

Although the people of Australia are more completely British in their origin than are the citizens of the United States, there is a remarkable contrast between the policies of the Governments of the United Kingdom and the United States on the one hand and of the Australian States on the other so far as the encouragement of engineering enterprise is concerned. In the Australian States the tendency has been to concentrate the construction and management of all works of importance under the immediate charge of the Government. Cases have occurred where private companies offering to construct useful public works entirely at their own risk and expense, have been refused the necessary authority on the ground that the works should be constructed by the Government, and that the construction of such works should await the convenience of Government. This spirit appears to be most developed in New South Wales, Victoria, and South Australia, and seems less pronounced in New Zealand and Tasmania. In New South

Wales, owing to the absence of local self-government, centralization has reached its highest stage. The construction of even a road culvert on the borders of Queensland or South Australia requires sanction from Sydney.

With comparatively trifling exceptions, the railways of the various States of Australia are constructed and managed by the State Governments. In some cases where land-grant railways were proposed, strong opposition to this system was raised, and it was apparent that this system as adopted in America would not be countenanced. This being the view taken in the various States, it appears strange that the Governments of these States, as the owners of the land, did not adopt some of the leading principles acted on by the land grant railway companies in that country. They might have proceeded with the construction of railways in advance of settlement, selecting the lines along which settlement could most advantageously take place, and disposing of the land in suitable areas as the railways progressed. The enormous losses which have occurred through settlers taking up land remote from communications and insufficient in area or unsuitable in quality and surroundings for the maintenance of themselves and their families, would have been, in a great measure, avoided if the Government had acted the part of guide and pioneer of settlement, as was done by the land grant companies of the United States and Canada. It is obvious too that this system would have been as advantageous to the Government as to the settlers. However, as a matter of fact, in all the Australian States, railways have followed settlement instead of opening the way for it. Throughout Australia the system under which the railways are constructed and managed has not been so long in operation as to warrant a final opinion as to whether it is the most advantageous. When the present Railway Act was carried by Sir Henry

Parkes, and Mr. Eddy was appointed Chief Commissioner, the administration of the railways of New South Wales was admittedly in a highly unsatisfactory state. Victoria and South Australia passed through similar experiences. The magnificent services of Mr. Eddy and the high state of efficiency to which he brought our railway system, gave a reputation to State management of railways such as it never had before in a British community. No amount of theorizing on the subject could have afforded such cogent reasons in favour of this system as were furnished by the practical results of Mr. Eddy's management.

With regard to the construction of Australasian railways this has been done chiefly in the past, and, so far as can be judged by present appearances, will be done entirely in the future by the various Governments. The only exceptions now allowed to this rule are short branch lines for mining purposes. It is worthy of passing remark that Mr. Eddy in New South Wales and Mr. Mathieson in Victoria, in their reports on the railways in these States, called attention to what is perhaps the most serious drawback to which this system is liable, namely the construction of lines which are not warranted from a business point of view. Special provision has now, however, been made for exhaustive inquiries before any line of railway is sanctioned, so that it is unlikely that sanction will in future be granted without ample reason. For the time at least the various Governments of Australasia appear to have settled this question to their satisfaction, and that being so, it is interesting to contrast their decision with that of the Government of the United States. When the question of a trans-continentâl railway first came before the Government of that country, it was referred to in the Message of the President in the following terms:—"It is freely admitted that it would be inexpedient for this Government

to exercise the power of constructing the Pacific Railroad by its own immediate agents. Such a policy would increase the patronage of the Executive to a dangerous extent, and introduce a system of jobbery and corruption which no vigilance on the part of Federal officers could either prevent or detect. This can only be done by the keen eye and active and careful supervision of individual and private interest. The construction of this road ought, therefore, to be committed to companies incorporated by the States, or to other agencies, whose pecuniary interests would be directly involved. Congress might then assist them in the work by grants of land or of money, or both, under such conditions or restrictions as would secure the transportation of troops and munitions of war free from any charge, and that of the United States mails at a fair and reasonable price." The policy here stated is substantially the policy still followed in the United States.

It may be mentioned here that in Germany practically the whole of the railways have been brought under the direct control of the Government. When it is considered that Germany is surrounded on three sides by powerful nations possessed of huge armies, that every man is a soldier, and that the country has to be in a state of complete preparedness for war; the advantages connected with the Government control of the railways in that country are at once evident. Although France also is a great military nation, its extent of land frontier liable to attack is comparatively limited. Probably owing in some measure to this, the ownership of the railways, as in England is left to private companies.

As regards works other than railways in Australia, it may be stated generally, that the towns have been nursed by the various Governments to an extent which has no parallel in the United Kingdom or North America. It is

on record that in one of the Australian States water supply works were constructed at Government expense for a small town, no charge being made for the water supplied, and that when a pump of very simple construction, in connection with these works, went out of order, a deputation promptly went to the Government to ask that repairs should be made. The Minister, as is usual on such occasions, informed the deputation that he would refer the matter to his officers. When returning to their town, the members of the deputation, after discussing the question, came to the conclusion that the Minister was not sufficiently impressed with the urgency of the case, and that his officers likewise, might not be in a hurry in attending to it. After further discussion, a member of the deputation suggested that it might be worth while to try whether the local blacksmith could put the pump in order, and it was agreed that the deputation should try this course on their return. They did so, and the village blacksmith, who was fortunately to some extent, at least, in accordance with Longfellow's ideal, offered to do his best, to ask for nothing if he should fail, and to make only a reasonable charge if he succeeded. The end of the matter was that the blacksmith successfully repaired the pump and charged seven shillings and sixpence for the work—an amount which was very much less than the railway fares of the deputation. Among people in the Western States of America who proclaimed that they "want no paternalism," the account of an occurrence like this would give rise to many reflections.

In New Zealand and Victoria systems of local Government are in force, and water supply and sewerage works of towns are to a large extent dealt with by municipalities. In New South Wales the towns depend on the Government for both classes of work; in fact, the people lean on the Government and depend on it for all classes of engineering

works to an extent unknown in any other community of British origin.

With regard to the important question of water conservation and irrigation, this is a branch in connection with which Victoria is the only State which has constructed extensive works. For the distribution of water from the rivers for stock and domestic purposes, a number of very useful works have been constructed by the Government of New South Wales, and much good has been done by this State and by Queensland in sinking artesian bores and exploring the country for artesian water; but as regards irrigation, Victoria alone has taken action on an extensive scale. It is necessary to mention that the number of artesian bores put down by enterprising landholders far exceeds the number put down by the Governments of Queensland and New South Wales, and that in the latter State alone, dams and other works for conserving water were constructed by the landholders at an estimated aggregate cost of over two millions sterling. Considering that many of these works were on land for which only a moderate tenure had been granted and that the works were constructed and maintained on sufferance only, it must be admitted that they bear excellent testimony to the enterprise of the pioneers who carried them out. In the United States and Canada the settlers own the land, so that the fruits of their enterprise in conserving surface water or putting down bores or wells are secured to them.

When an energetic and comprehensive irrigation policy was decided on in Victoria, the system which was adopted of having all but the largest works constructed and all the works managed by Irrigation Trusts was excellent in theory. It was expected that the money supplied by the Government on loan would be judiciously and economically used by the Trusts, as they were to be responsible for the pay-

ment of interest on it. So also, it was expected that the Trusts would manage the distribution of the water to the best advantage and to the satisfaction of all parties concerned. What actually happened was very different. In a number of cases the money obtained from the Government was spent very injudiciously, and in some it was absolutely wasted. Eventually an Act was passed under which a million sterling was written off as useless or unprofitable expenditure from which no return could be expected. The whole system of management by Trusts created and fostered by Government cannot be regarded otherwise than as a costly failure. This is not due to any failure on the part of the landowners to appreciate the benefits of irrigation. As a matter of fact, the landowners are anxious for more water and for further extension of the works. Still, even with the relief already afforded by the Government, the condition of affairs is far from satisfactory. The whole position is in remarkable contrast with that in California, Colorado, and other Western States of America. In these States, where the Governments did not contribute a single dollar in aid of irrigation, the progress made has been far greater than in Victoria, and the results have been highly satisfactory to all parties concerned. With reference to these results, one of the representatives of California at the Irrigation Congress already referred to, asked the question "What would California have been today as far as beautiful homes and fine fruit trees are concerned, had it not been for private enterprise combined with private capital?" It is interesting to compare the feelings which prompted this question with the spirit displayed at the recent Irrigation Conference at Corowa, where representatives of Victoria, South Australia, and New South Wales were in attendance. The Conference was initiated and organized by representatives of the last-named State, and they were mainly responsible for the

drafting of the resolutions which embodied the results of the deliberations. In these resolutions the effects of what the Americans term "paternalism" were a prominent feature. The representatives asked that the Governments of the States should take action separately in one direction, collectively in another, and in unison with the Federal Government in another; but there was not the least indication that the people were either able or willing to do anything by themselves. When the landholders of India reach the stage at which they will begin to hold Irrigation Conferences, it will be easy to imagine such a conference, at say Agra or Lahore, passing resolutions closely corresponding in character to those passed at Corowa. On the other hand, those resolutions would sound strangely if repeated before a conference like that held at Los Angeles, where the spirit of the representatives was most clearly indicated in the phrase "We want no paternalism."

Various considerations led me to take up the subject of the systems under which the principal engineering works are constructed and managed in different countries. In the first place, so far as the development of the resources of New South Wales and of Australia generally is concerned, the country is still in its early youth. It is out of the question at our present stage to imagine that we have arrived at the best systems for utilizing these resources, just as it would be absurd to conclude that we have nothing more to learn from other countries in regard to the construction and management of engineering works. It may be urged that the system under which large engineering works are or should be constructed is a political question, and so it is to a certain extent. For this reason I have adhered to simple facts and the conclusions directly deducible from them, and have avoided the advocacy of any particular system. Probably there is not much in what I

have stated that is new to you; but the mere statement of the facts may bring new aspects of the question to your minds as it certainly has to mine. For instance, till now I never remarked the resemblance between the people of New South Wales and those of India in their attitude of passive and patient waiting for the action of the master hand of a paternal Government.

Another point which had some effect in prompting me to take this subject was that for the engineer and particularly for the young engineer, the world is his field; so that the practice followed in the initiation of engineering works in different countries is a matter of much interest. I may here remark that as regards our young engineers, it seems strange that in such a young and undeveloped country as Australia, the prospects of an engineering career should seem to some of them less promising here than in England and elsewhere. It seems also strange that the great majority of the engineering students in the Sydney University should devote themselves to mining engineering, a branch in which they will be free from Government interference and Government competition.

As I have already stated, it was quite impossible for me to do more than give a few fragmentary outlines of this most important subject. It seemed to me, however, that in such an address as this, though I could not convey much information that is new, I might draw attention to the question in a way that would assist in giving rise to a spirit of inquiry and investigation regarding it. If I have succeeded even in a moderate degree in doing this I shall be perfectly satisfied.

THE IMPORTANCE OF FEDERAL HYDROGRAPHY.

By J. HAYDON CARDEW, Assoc. M. Inst. C.E.

[*Read before the Engineering Section of the Royal Society of N. S. Wales, June 18, 1902.*]

THE practice of hydrography and the study of hydrologieal questions is of such great importance and value to the people of Australia, that it is open to discussion whether the Federal Government ought not to make it a national undertaking in the same way as it is proposed to form a Federal Meteorological Department, in order that all the States may have the advantage of that fuller knowledge which a comprehensive national survey of the question over the whole continent would ensure. Unfortunately in this State and in most of the other States of Australia this important science has not been systematically pursued, although there is no country in the world where the results arising from such a course would have proved more valuable.

The author does not wish in any way to depreciate the labours of many eminent observers in this branch of science, the services rendered by them are invaluable, and reflect upon them the highest honour, especially in view of the many difficulties they had to encounter owing to that want of system here alluded to, and also to the multiplicity of their other duties, but as the respective efforts of these observers have been directed only to portions of this great question, and in some cases in a disjointed and intermittent manner, and as the results have not been collated and published the full benefit of their labours is lost to the public.

In most European countries and notably in the United States of America, professional men, principally trained engineers, are engaged upon this question all the year

round, and in most of these countries it is considered to be of such importance as to form a division or branch of some Government Department. In the United States it forms a division of that great work, the United States Geological Survey, the annual report of which runs into many volumes, one volume of 750 pages profusely illustrated being entirely devoted to hydrography.

The subject is naturally so akin to geology that a combined research of both subjects can be carried out more economically than when separately considered, but to be of any value to the State it must be pursued systematically and comprehensively over the whole of the Commonwealth and the results periodically published. It is of very little national value to undertake isolated researches into the hydrology of a river basin here and there, or to record the rainfall without a close study of the rivers and atmospheric effect, or to make any observations at all which are pigeonholed in some public department and thence forgotten.

This State is much indebted to Mr. H. C. Russell, B.A., C.M.G.; F.R.A.S., Government Astronomer, for his researches in many branches of hydrological science, and to his efforts in establishing so many rain gauges in different parts of the country and for his very valuable compilation of Rain, River, and Evaporation Observations, but to be of any real value to the engineer the observing stations require to be greatly increased so as to embrace every principal creek and river basin in the State.

Mr. H. G. McKinney, M. Inst. C.E., late Engineer to the Water Conservation Branch of the Public Works Department, and the officers of that branch have also performed much valuable work in the examination of some of our rivers, but, the results of which are unfortunately, only to a small extent accessible to the general public. As regards our artesian wells the Superintendent of Public Watering

Places has compiled a large amount of useful data respecting our resources in underground water, but in perusing the reports of some of the observers referred to we find complaint of the lack of reliable data and indirectly a plea for what the author advocates in order to make the reports more complete and definite.

The Government Astronomer says, in his Rain and River Report of 1895, "In attempting to measure the quantity of rainfall which the Darling carries off we are still met with the want of necessary data as to the velocity of the current and the area of the river channel." Again in speaking of the estimates of the water passing down the western rivers, he says, "Before accuracy can be obtained detailed surveys are absolutely necessary, also daily records of the velocity of the current." He repeats this in his 1899 report and adds the following significant statement, "At present we have only old sections of the river and an approximate velocity of current, and I assume that the Murray catchment in Victoria receives the same quantity of rain as that in New South Wales, and that the Queensland portion of the Darling catchment receives the same quantity of rain as that in New South Wales." Again in his last published report of 1899, he says in referring to the discharge of the Darling, "In the absence of a river section at the weir it is impossible to estimate the percentage of rainfall which passes Bourke." Also in pointing out the effect of altitude upon rainfall, which he states is a very material factor in the quantity received, he says, "for the great majority of stations this (the elevation) is an unknown quantity," and in another place, "I am fully convinced that a complete record of the rainfall will enable us to forecast the seasons with some show of success." Nothing could be stronger than the foregoing evidence as shewing the necessity and importance of a systematic and comprehensive study of hydrography.

Mr. Boultbee, in his report on Artesian Boring in New South Wales, page 5, referring to the enlargement of our geological knowledge and the delimitation of the artesian area says, "The demand made upon his time by the multifarious duties imposed on him do not permit our Government Geologist devoting that time to this important branch of geological survey which it demands, and which he desires." Again on page 7, referring to mapping of the artesian area "the area is so vast, and the labour expended so slight in proportion to it, that a great element of uncertainty still must necessarily exist which can only be removed by comprehensive detailed work." Regarding legislation, he says, it "has been lamentable, weak, inadequate, and was introduced without data sufficient to affirm the necessity for it." The introduction to the same work by the Minister for Public Works contains the following—"We fully recognise how much we have still to learn, and how little we have been able to do, regarding the investigation so necessary into the complex and scientific questions arising regarding the flow, the pressures, and the limit of interference one bore with another." The author places this evidence before you as being the experience of those who have dealt practically with some branches of the subject, and who must have felt acutely the want of systematic research in the whole realm of hydrography.

In order to eliminate the uncertainty and inefficiency of present methods and to acquire that complete knowledge of hydrology so essential to our welfare, let us first review what may be termed the elements of the subject, and afterwards note their individual importance and bearing on questions that require solving. The essential elements of hydrography are:—

1. The systematic gauging of rainfall and the collection of statistics as to its distribution and precipitation.

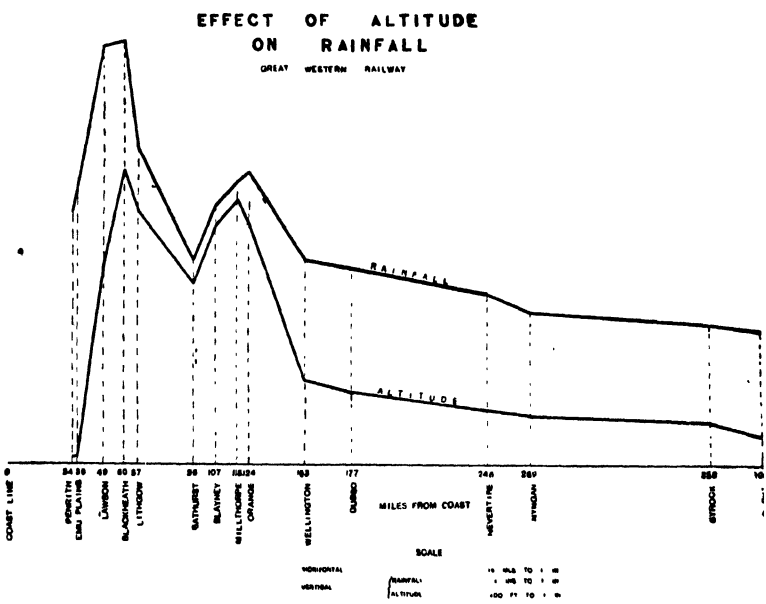
2. The systematic gauging of creeks, and rivers, noting the occurrence of floods and determination of flood heights and stream discharges.
3. The measurement of evaporation from land and water.
4. Determination of percolation in different soils and strata.
5. Determination of efflux or run off from catchments.
6. Recording phenomena of artesian boring.
7. Recording tidal phenomena and determination of mean sea level.

In connection with the ascertainment of the rainfall it is necessary to fix the altitude of the rain gauge above sea level, that comparison may be made of the effect on the rainfall of difference of altitude, and also the distribution of the rainfall should be carefully noted for different seasons of the year. In connection with the determination of efflux from catchments and the torrential character of a basin it would be necessary to define the area of each creek and river catchment, classifying the areas consisting of flat impermeable strata, sloping impermeable strata, and impermeable strata with notes as to vegetation and cultivation; the statistics of each valley of the basin should be separately recorded in order that the nature of flow of each tributary of a river and the influence of the tributary on the main river may be studied if necessary. In addition to the tabulation of the data thus obtained, the preparation of maps of the river basins illustrating by suitable shading the nature of the strata and the distribution of the rainfall would convey a great deal of useful information at a glance.

With regard to the observations for rainfall, I have already said that for the benefit of the engineer the observing stations require to be greatly increased; at the present time there are 1,724 official rain gauges in New South Wales, and as the area of the State is 310,700 square miles, they average only one to each 180 square miles, this pro-

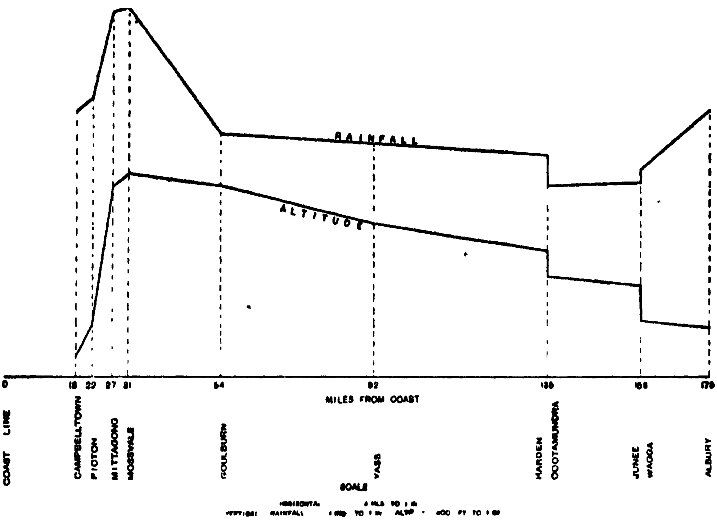
vision may be sufficient to give an average idea of the rainfall for a large district, but quite insufficient for an exact statement of the rainfall over any particular river basin or tributary; again the altitude of the majority of rain gauges not having been determined considerably discounts their value, as for instance in the determination of rainfall over a catchment area of fluctuating level, here the existence of one gauge might afford an idea of the rainfall on other parts of the area at greater or less altitude than that of the observing station, if by a series of observations elsewhere the ratio of increase or decrease of rainfall had been determined for increase or decrease of altitude.

Investigating this question of altitude on rainfall the author was much struck with the relation existing between them on the line of the Great Western and Great Southern Railways, and also along the line of the Dividing Range



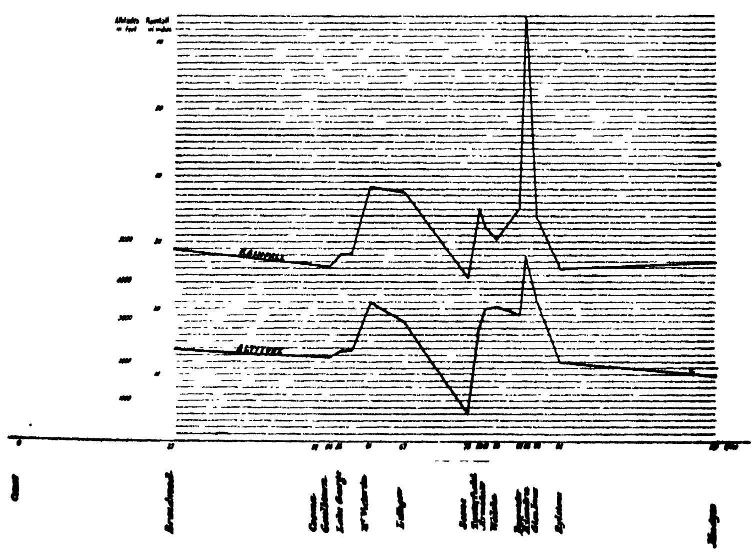
EFFECT OF ALTITUDE ON RAINFALL

GREAT SOUTHERN RAILWAY



EFFECT OF ALTITUDE ON RAINFALL

ALONG THE DIVIDING RANGE



from Tenterfield on the north to Cooma on the south, and now exhibits for what they are worth the diagrams of the experimental plotting; it will be seen how very closely the curve of rainfall conforms to the curve of altitude.

Time did not permit of a fuller investigation of this interesting question, but more data than the author had at his disposal would be necessary to arrive at any result regarding the ratio existing between increase of rainfall and increase of altitude, it can only be said as Mr. Russell puts it, that altitude is a material factor of the rainfall, what that factor is, hydrography only can supply, but these diagrams shew what great fields are open to the exploration of the hydrographer.

The question of river gauging, occurrence of floods, and the determination of flood levels and stream discharges taken in conjunction with the rainfall opens a very wide door for enquiry and research.

The Water Conservation Branch has done something in this branch of the subject, and Mr. McKinney established flood gauges in our western rivers, but only the fringe of of the question has been touched, and that in a very disjointed and fragmentary manner. In respect to flood gauges it is feared we are worse off than for rain gauges, and yet if, as is now generally conceded, it is important to know the amount of rain that falls, how equally, nay, how much more important it is to know the amount of rain that the rivers discharge. For of the two, it is infinitely more important to engineers who are about to project water conservation or irrigation works to know what is the daily stream flow measured over a long series of years than to have an accurate record of the rainfall. For such purposes the relation between rainfall and river discharge is often useless, because some rivers discharge during the rainless season a great deal more than the amount of rain that falls

on the entire drainage area and which had fallen perhaps months previously.

Of course the author does not wish to infer for a single moment that an analysis of the flow of a river and the yield of rainfall from the catchment is of no value, on the contrary, such investigations have the greatest value in other directions. The velocity and volume with which water will flow off steep mountainous slopes is one of the latter, and a very important one when a reservoir is to be formed in a valley, the safety of the dam being dependent upon a true perception of the natural laws governing this question; to the lack of this information may be attributed the destruction of many dams on account of the insufficiency of waste weir provision.

The author was met with this very difficulty when reporting upon a project for the supply of water to the Lloyd Copper Company Ltd., for their ore reduction works at Burraga; no authentic information was available as to the efflux from the catchment, but after a careful examination of the physical features and the geological nature of the district, he assumed that 65% of the average rainfall (assuming the mean annual rainfall of 28·8 inches at Burraga $2\frac{1}{2}$ miles away, as being the average rainfall for the whole catchment) was lost by absorptive and evaporative agencies. Just before the dam was completed an opportunity occurred to the author of actually measuring the amount of rainfall contributed to the reservoir, which proved that $78\frac{1}{2}$% of the rainfall was lost on that occasion by evaporation and absorption on the catchment. It may be interesting to describe how this was done.

Rain commenced to fall 19th September 1901, the ground surface being fairly moistened with the winter rains and snows, but not by any means thoroughly saturated, the rain terminated 26th October, and during that period 4·78

inches of rain fell, of which 2·65 inches were contributed in one day as recorded at the Burraga rain gauge; for this rainfall the precipitation on the catchment would represent 577 million of gallons. The reservoir was empty when the rain commenced and was full on the 10th December up to the level of the overflow weir, at which date the streams leading thereto had ceased to flow; during the period of contribution 35 million gallons were run off by the contractor, which quantity was measured through the sluice pipe; $4\frac{1}{2}$ million gallons were evaporated from the reservoir calculated on the assumption that the evaporation was the same as Mr. Russell gives for Lake George, viz., 40 inches per annum, the conditions of the two places being apparently similar, and 85 millions of gallons remained in the reservoir, so that in all, the catchment contributed $124\frac{3}{4}$ millions of gallons to the reservoir, or about 1 inch out of the total rainfall of 4·78 inches, therefore the proportion of the rainfall conserved at this period was $\frac{124 \cdot 25}{577} = 21\frac{1}{2}\%$; it may readily be conceived that after a long drought or in the heat of summer the percentage conserved would be less, as the absorptive and evaporative agencies would be more active, and in the winter when the bulk of the rainfall usually occurs, it might be more; the results of the test satisfied the author that the length of waste weir he had provided was sufficient to discharge the heaviest rainfall likely to occur, and did not materially disturb the calculations regarding the amount of water available for conservation.

In a country like Australia, having vast areas of what may be termed arid lands with scanty and irregular rainfall, is of the utmost importance to know not only the amount and distribution of the rainfall, but also what becomes of it, and that at once introduces the consideration of the questions of evaporation, percolation and efflux from river basins; without a consideration of all these taken

together systematically and comprehensively over the whole of this and the adjoining States, we cannot solve the riddle of our western rivers and what becomes of the rainfall. At the present the whole of our deductions are largely based upon assumption and guess work, as has been admitted, and in the author's opinion, the discrepancy existing between the rainfall and discharge for the rivers aforesaid has never been satisfactorily accounted for, and until a complete system of hydrographical observation is established for the whole of the basins of these rivers it never will be possible to devise a system of irrigation and conservation until these questions are scientifically dealt with and solved. On the other hand the possession of such knowledge regarding these rivers would enable the engineer to project with confidence any system of irrigation, and would enable him to determine with accuracy the magnitude of the works required, therefore the hydrographer should precede the engineer, and as his work requires time for maturity, he should have a long start of the engineer.

One of the important considerations in designing irrigation works and especially storage reservoirs, is the maximum amount of rainfall that may occur in any period of time; great floods are the immediate result either of the sudden melting of snow, or of heavy rainstorms coming perhaps after a period of wet weather when the ground is fairly saturated, and statistics showing the rainfall in 24 hours are often insufficient to give a safe estimate of what may be precipitated in sudden storms. Mr. Russell records a rainfall in 24 hours at Arnold Grove, 28th May, 1889, of 11·13 inches, and again 10·08 inches on 20th March, 1892, which in the first instance represents 26%, and in the second instance 24% of the mean annual rainfall; again at Albion Park on the 8th February, 1895, he records a fall in 24 hours of 10 inches, or nearly 22% of the annual rainfall; an

investigation of a great number of other rainfall returns shows from $\frac{1}{8}$ to $\frac{1}{10}$th of the mean annual rainfall as being the greatest rainfall in 24 hours, but there is nothing to shew what proportion of these heavy falls occurred in a period less than 24 hours, and yet for the determination of the capacity of spill ways to reservoirs with limited catchments, or for culverts on roads and railways it is absolutely essential to have such data. The author has observed in many settled districts of New South Wales away from the coast, that the maximum rainfall for 1 hour fairly approximates to $\frac{1}{4}$ of the maximum daily rainfall, and that for a period of 8 hours the maximum rainfall is double of that for one hour, and he has constructed works upon that general assumption, but it must be admitted that the treatment of the question in this manner is not always conducive to good practice.

The determination of the efflux or "run off" from a catchment is a very important one to the engineer when designing water ways for railways or roads, but it is so intimately bound up with the question of rainfall, the slope, and permeability or impermeability of the strata, the amount of vegetation, and the effects of evaporation that it is peculiarly one for the determination of the hydrographer, and if such information had been available before our railways had been built, one would have no hesitation in saying that a vast amount of public money would have been saved, both in the curtailment of unnecessarily extensive works or by the provision of more ample means for the passage of water; the same thing may be said of all works carried out by our municipalities, which have lost large sums of money by actions at law consequent on the neglect of the study of hydrology.

Again the systematic gauging of the rainfall, the regular daily observations of our rivers, the measurement of evapor-

ation, percolation and efflux would be an invaluable aid for the prediction of floods; when the nature of a tributary's basin is known, it is possible to forecast the effect of any storm upon the main river, and by constant observation of all the tributaries of the river, to arrive at a perfect system of prediction of floods, so that the settlers and towns along the banks may be warned in time to make preparation against loss of life and property.

In this connection Mr. C. J. R. Williams, Assoc. M. Inst. C.E., in an admirable paper read before the Institution of Civil Engineers in 1899 gives a very interesting account of the manner in which floods are predicted in the Brisbane River by the aid of hydrography; he describes how by flood gauges in the main stream and its branches, all connected by levelling, with accurate cross sections of the channel, the gradient of the stream when normal and in flood, and with the observed current velocities at different heights, it is quite possible to give an accurate prediction of the height and time of the flood well in advance of its arrival; a comparison of the calculated and observed heights of the actual flood levels show marvellously accurate results, but of course an immense amount of information, involving perhaps years of observation is necessary for such a purpose, however the cost and labour is amply compensated for by the insurance which it provides against all kinds of loss. In the same way we can acquire knowledge which will enable us by the construction of balance reservoirs so to regulate floods as to greatly ameliorate the effects of drought.

Again the results of hydrological study would be very beneficial for the adequate provision of water supply to large towns, and if proper attention had been paid to this science the Prospect Dam would not be in the very serious condition it is to day, and the lamentable troubles and

deficiencies of the Bathurst and Goulburn water undertakings might well have been avoided. It may be urged that the cost of such an extensive work would be prohibitive, but it need not be, the concentration of the work under one head, say that of the Geological Survey, of which it rightly forms a part, would allow of a very much larger amount of work being performed for the same cost as the disjointed efforts at present entail, and on the other hand the money expended on the acquisition of this knowledge would be recouped in a thousand ways, as I have already shown; the Government have road engineers and surveyors in every part of the country, who would make very many of the necessary observations; flood gauges could be maintained and observed by Government employees on river punts and elsewhere, and even much despised private enterprise could be enlisted in the same way as Mr. Russell has done with such splendid results.

The present drought is estimated to cost Australia 130 millions of money, and if, as the author firmly believes, such a study would point the way to save such awful losses in the future, are we not criminally neglectful in not having put our hands to the work long ago?

The advantages that would accrue from a comprehensive hydrographical survey such as herein indicated with the records presented annually in a consolidated form must be obvious, especially when your attention is drawn to the fact that now such information has to be sought for—and often in vain—in the scattered reports of several departments: if such a course was adopted the pastoralist, the agriculturalist, the miner, and the engineer could have the records upon their own bookshelves for reference. Ancient and contemporary history both reveal to us the great importance that has been attributed to this science by all civilised nations in all ages, and the certainty of the recur-

rence of such droughts as the one we are now suffering from, should enforce upon our serious consideration the necessity of taking immediate steps to acquire that complete knowledge whereby alone we can hope to alleviate the miseries and losses of our people in the future.

In submitting this paper to your consideration, the author feels confident that even if all he advocates does not meet with entire approval, the broad question of Federal initiation and maintenance of hydrography in the States of the Commonwealth is worthy of discussion at your hands.

RECENT DEVELOPMENTS IN HIGH SPEED RAILWAY CONSTRUCTION AND WORKING.

By C. O. BURGE, M. Inst. C.E.

[*Read before the Engineering Section of the Royal Society of N. S. Wales, August 20th, 1902.*]

A paper on this subject cannot have so much immediate practical interest to us in Australia, where, as regards railway speed, we are slow going, as that on hydrography at our last meeting. But it is very desirable that we should know what is going on elsewhere, in the progress of time saving work, in anticipation of the demand for it here. A recent visit to Europe enables me to place before the Royal Society a summary of the progress within the last few years in methods for achieving rapid land locomotion.

As regards speed of the long distance trains in the United Kingdom, there does not appear to be much demand for a higher through speed, including stops, than 50 miles per hour. From London to Glasgow, Edinburgh, or Dublin, is

now covered in 8 hours, *i.e.*, an afternoon and evening, or else a night, and there is hardly any conceivable speed, taking into consideration the fatigue necessarily involved, which would practically diminish the time now withdrawn from business by the present service.

Both in the House of Commons enquiry last year, on the Manchester and Liverpool Express Railway project, and having regard to other engineering opinions, it is very generally admitted that the limit of speed on ordinary steam locomotive railways has been now nearly reached. This is partly on account of the impossibility of increasing the size and weight of the engine to obtain the necessary power, without reconstructing, by widening and strengthening, the lines, and partly on account of the reciprocating action of the propelling machinery and its inferior accelerating power. There is also the impossibility, unless a special high speed line is proposed, of adjusting the superelevation of the outer rail in curves to great variations of speed.

The proof of these two facts as regards the United Kingdom, the absence of great demand for higher speed than is obtained at present, and the practical difficulty of attaining it at profitable cost, is to be found in the fact that though there is keen competition between the London and North Western, Midland, and Great Northern railways to the north, the through speed has not practically exceeded 50 miles per hour for some years back. In fact, the great additional power provided in the modern passenger locomotive over its predecessor, is expended not in increased speed, attained years ago with a limited number of light trains, but in maintaining it with a greater number of trains with heavier vehicles. Many of them contain complete restaurant and sleeping accommodation and other comforts, all implying great weight, on which, rather than higher speed, the public have insisted.

The high speeds of over 100 miles per hour now so much talked of, are looked for, as far as the United Kingdom is concerned, in short lengths between thickly populated centres, such as Manchester and Liverpool and Sheffield, London and Brighton, Edinburgh and Glasgow, etc. And if, by the aid of electricity, this speed is successfully reached in these cases, long distance express lines of the same character may be possible in the future on the Continent of Europe and in America. The element of human endurance, however, must be taken into consideration unless provided for by a very much more elastic permanent way, and easier running rolling stock than exist at present.

The extraordinary progress in electric traction, the possibilities as to its power not being limited, as in the steam locomotive, to what can practically be contained in the train itself, but which can be expanded to an enormous extent in a central power house; and its greater capabilities in acceleration and retardation, have led to several proposals for high speed railways, by this means. These are to be used for express passenger traffic only, between such crowded centres as have been mentioned, viz., Manchester to Liverpool, London to Brighton, Berlin to Sozzen, Brussels to Antwerp and Vienna to Buda-Pesth.

The main features of the construction and working of some of these lines are, that many of the most frequent causes ef accident, which would be the more disastrous owing to the great speed, are enabled to be eliminated. These features are (1) constant speed, (2) fixed intervals between trains, (3) absence of intermediate stations, sidings, cross over roads, or level crossings, and (4) single car trains.

It is evident, that, owing to the constant speed, the superelevation of the outer rail on curves may be exactly conformable to that speed, and not a compromise, as on ordinary lines for mixed traffic of various speeds. Hence,

as far as centrifugal force is concerned, derailment or unequal pressure on rails is less liable on such express lines, notwithstanding the speed, than on ordinary ones. Then, if the constant speed from end to end, and fixed intervals between trains are duly maintained, combined with the non-existence of points and crossings, there can be no collisions, while, owing to single car trains, there can be no breaking of couplings. The causes of accident therefore are limited to derailment through effects of curvature, other than centrifugal force, to defects in the substructure of the rolling stock or in the road, and to obstructions upon the line. As collisions usually cause the greatest disasters on railways, the immunity from these is a great point. As regards derailment through curvature, Mr. Behr, in his proposed line from Manchester to Liverpool, is adopting the mono-rail system, by means of which he expects to run his cars safely round 30 chain curves, at 110 miles per hour, and he has actually attained, on an experimental line at Brussels, 83 miles per hour on a 25 chain curve. The Brussels to Antwerp proposal is also on this principle, but the other lines mentioned which are on the ordinary bi-rail system, escape the curvature difficulty by making the alignment practically straight. Derailment from defects in the cars, and in the road, can only be avoided by increasing their strength and solidity, and from obstruction on the road, by more effective fencing, and watching, matters of expense only.

Though the liability to accident is greatly reduced on these special lines, certain discomforts to passengers arise from the great speed. In order to save time, and to utilize as much as possible, the whole length of a short line for the maximum speed, the acceleration and retardation at beginning and ending must necessarily be severe. As much as 4 ft. per second per second is proposed on the first

mentioned line, this meaning, at a speed of 110 miles per hour, a pull up in 1,000 yards and in 37 seconds, the maximum at present, with ordinary express speed, being not much more than half of these. The question is, whether a passenger, facing forwards, would not be thrown into the arms of his vis à vis, by such a sudden stop.

Another inconvenience is that which will be caused to the passenger by excessive tilt on curves. In order to have the resultant between gravity and centrifugal force normal to floor of vehicle, at 110 miles per hour, on a 30 chain curve, as sanctioned on the Manchester Liverpool line, the car will be tilted 22° out of the vertical, while on the curve, and a 12 stone passenger would become virtually a 13 stone one pressing at that angle on his seat, that being the resultant between his weight and the 67 lbs. of centrifugal force acting upon him. If, as proposed on that line, the seats are longitudinal, that is to say omnibus fashion, the effect would be decidedly unpleasant, and possibly dangerous, as the swing from the vertical position of the car on the straight to the 22° of inclination on the curve, even if long easing curves were used, would be very sudden, as about 2½ chains would be passed over in a second of time. Such sharp curves, however, would not be possible, under such speed, for other reasons, on a bi-rail line, and with easier ones, and with cross seating, the effects would be greatly diminished.

The mono-rail system has no *raison d'être* for high speed traffic, except as regards this superiority in holding the train on to the road, in sharp curves, and it has so many disadvantages as will presently be explained, that if there is sufficient demand for such speeds, the expense in constructing a nearly straight ordinary bi-rail line would probably be justified rather than incurring of those disadvantages.

The Manchester and Liverpool Express Mono-rail electric line is, except for experimental purposes, the first in the field, and apart from its special mono-rail form, it is a good representation of the class. As also I had special opportunities by attendance at the House of Commons Committee last year, and by intercourse with its promoters and opponents, I shall briefly describe it:—The length of the line, which is a double one, is 34 miles 33·60 chains. The grades are practically level, except at each end, where 7 chains of 1 in 25 at Manchester, and 8 chains of 1 in 30 at Liverpool, are purposely introduced for acceleration and retardation purposes. There is one curve of 30 chains radius, and only three sharper than 40 chains. Ten of the curves are less than 80 chains radius. The construction, up to the top of the sleepers, which are to be 9 ft. × 10 in. × 5 in., is the same as that of an ordinary railway. On each of the sleepers, which number 1,610 to the mile, is constructed a triangular braced trestle of built steel, striding 3 ft. at foot, 4 ft. 6 in. high, supporting on top the single 100 ℔ bull headed rail, which bears the load, and gives its name to the system. At each side, on the slope of the trestle, two 30 ℔ guide rails are set horizontally, making a total weight of rails, for each line of way, of 220 ℔s. to the yard. The formation is 26 ft. wide, and the two lines of way are 12 ft. 6 in. apart, centre to centre. The clearance between cars is only 1 ft. 6 in. The electrical equipment includes, besides these, four rails as feeders, one at each side of each line of trestles. The predicament therefore, of a fettler, between the two, surprised by the approach from each direction of cars only 18 inches apart at a speed of 161 feet in a second, on the top of these fence-like, and electrically charged trestles, can only be compared to that of the man who had hold of the tiger's tail, and did not know whether to hold on or to let go.

The explanation of the promoters in defence of this that repairs will only be done at midnight, when there will be no traffic, will hardly satisfy the Board of Trade, who will probably insist on a greater clearance. The trestles are of angle steel $3\frac{1}{2}$ square inches sectional area, strongly braced, and are to be tilted on the curves, so as to absorb the centrifugal force due to the speed. To prevent the too quick generation of this force, long transitions or easings of the straights into the curves are to be introduced. As the electrical equipment includes, as already mentioned, one line of 100 lbs. rails at each side of each line of trestles as feeders, making a total of 840 lbs. of rails per yard, it will be seen that not only the first cost, but the maintenance, of the running road will be costly. Owing to there being no sidings or points, disabled or superfluous rolling stock must be transferred from rail to shop, by being lifted off by a crane, and vice versâ, or by a dead end off the turntable, one of which is provided at each end of the line, to transfer cars from down to up road or vice versâ.

It will be seen that, unless very great care is taken in the maintenance of this road, dangerous sinuosities will take place in the alignment of the rail. In the ordinary permanent way, a slack or depression, in one rail of say one inch, affects the vehicle passing over it vertically to that same extent and more, and a certain oscillation is set up. But in the case of the trestle, a vertical slack of one inch in the same position, laterally, of the road bed, would slew the bearing rail nearly two inches over and horizontally, giving a dangerous lurch to the car, which at the proposed speed, might cause much damage to the structure and possible accident. Of course great care would be taken in the maintenance of such a line, but the possibilities of the neglect of it cannot be left out of account. The trestles, sleepers, and rails, not including the feeder rails,

which are part of the electrical equipment, are estimated to cost £13,500 per mile.

Two alternative sizes of cars are proposed, one 35 tons loaded, taking 35 passengers, and one of 50 tons taking 50. They are designed to be on two bogies of three tandem wheels each, the leading wheel of one and the trailing wheels of the other being flangeless drivers, whose axles are geared, by case-hardened sprocket chains, to four 3 ton motors, hung at a lower level, horizontally between the guide wheels. The maximum speed of the chains will be as much as 1,960 feet per minute, transmitting 375 HP. The guide wheels of the car are eight in number, two pairs at each side of each bogie, the upper one 19 inches and the lower one 35 inches below surface of the bearing rail. They and the 30 lb rails they work on, are horizontal and not normal to the sloped side of the trestle, to which the latter are attached. Each guide wheel has its own axle, so that the differential revolution in curves is provided for, that cause of derailment and friction on bi-rail lines being entirely eliminated. These wheels are provided with $\frac{5}{8}$ in. flanges at lower side to resist overturning tendency. Springs are to be used to maintain contact between guide wheels and rail, but unless these springs are so perfectly adjusted as to take up fully any rolling motion set up in the car by any of the numerous causes of it, intermittent contact will ensue, which at such speed would soon destroy both rail and wheel.

The underframes of the car are of steel, and the framework of the upper portions is of a special alloy of aluminum of about 2·50 specific gravity, so as to keep the centre of gravity of the car 12 inches below bearing rail, a condition laid upon the promoters by the Lords Committee. The 50 ton car is 41 feet long, for 25 feet of which it has parallel sides, the remainder forming pointed ends, to diminish air

resistance. They are 11 feet wide and have end doors, the total height over rail being 7 ft. 1 in. The seats, which are about 4 feet over the bearing rail are arranged omnibus fashion—two rows on each side.

The motive power originates in a power house at Warrington, which is midway. The current is to be generated at 500 volts by three phase alternators, transformed up to 15,000 volts, and transmitted to five substations, where it is reduced, by static transformers, in parallel, to 320 volts, then transformed by two rotary converters connected on their continuous current side, to continuous current at 500 volts on the three wire system. The feeders, as before referred to, are two 100 lbs rail conductors placed one at each side of each road, so that there will be a difference of potential of 1,000 volts between these and the running rail, forming the return, viz. 500 volts P.D. between terminals of any motor. The current is collected by shoes, and feeds the motors, which are each of 140 HP for the 35 ton car and 187 HP for the 50 ton car, but capable of about double that power for short periods. The armatures will work at the same speed as the driving axle, viz 720 revolutions per minute.

The braking is to be effected in three ways—First, by a high speed Westinghouse brake, which can exert a retarding force of 4 ft. per second per second, and would stop the car, at the maximum speed, in about 1,000 yards. Secondly, electric braking by reversing motors and turning them into dynamos exerting a retarding force of 3 ft. per second per second. These two combined would stop the car in 33 seconds, in 900 yards. Third, a magnetic brake to be used on great emergency only, acting on bearing rail. There was much evidence before Sir Lewis McIvor's Committee, in the House of Commons, as to brake power for these high speed single car lines, but it was generally agreed that the

difficulty would not consist in want of sufficient brake power, but in the application of it without danger, or at all events serious discomfort, to passengers.

As to signalling, it is proposed to have signal stations worked electrically, about seven miles apart, with a man at each. The passage of a car automatically raises the the signal arm, and the one seven miles behind, to danger. The turning of the turntables at each end which transfers the car from the up to the down line, and vice versâ, also actuates the signals behind them. The signals, thus set at danger, automatically act on a following car which for any cause has not been pulled up, by a current breaker which rings a bell in the car and also sets the electric brake in action. Diagrams shewing the working of these arrangements are appended. The intervals of seven miles, or in time of 3 min. 48 sec., during which they are passed over, have been fixed to suit a 10 minutes service, so that there is a considerable margin of safety.

The capital of the Company is £2,800,000, being £2,100,000 in ordinary shares, and £700,000 in debentures. The estimate is—

Construction and rolling stock (10 cars) ...	£1,286,000
Electrical equipment	464,000
Land and Parliamentary expenses	1,050,000
Total ...	2,800,000

For a ten minutes service of 90 trains daily, and 45 on Sunday, the promoters estimate working expenses at 7·47d per car mile. Compared with ordinary train service, the running wages will be very low as the mile is worked for about half a minutes' wage but the power is necessarily high due to the speed. The fares, one class only, are to be 2/6 single journey, which with the expected number of passengers, 4,000 per day, would give a return of 5 per cent. on the capital.

The objections to the mono-rail (which ought really to be called the penta-rail, as there five rails to each road), as exemplified in the Manchester and Liverpool scheme, seem to me, to be, as under :—

First—Great expense in construction.

Second—Practical difficulties in loading each side of the car equally, without which unequal friction will take place in working of guide wheels, leading to the next objection, viz.

Third—Dangerous interruption of contact between guide wheels and side rails, and recontact at high speed, which may not be effectively prevented by the springs.

Fourth—Effect of centrifugal force on passengers with omnibus seating.

Fifth—Danger to workmen caught between the rails by passing cars.

Sixth—Slack at one end of sleeper leading to dangerous horizontal sinuosity in the bearing rail.

Seventh—Unprecedented speed of chain gearing at nearly 2,000 feet per minute, double the maximum usually in operation with similar gearing, probably dangerous, certainly noisy.

Eighth—Costly maintenance.

Notwithstanding that some of these objections were put before the Committees, they passed the bill, guarding it, however, with more stringent conditions than is usual with railway bills, as to submission of plans etc., for approval of the Board of Trade. The company have got an amending bill through Parliament this session as regards a small deviation, and as a contract has been entered into for construction, it is probable that the line will be shortly commenced, and, though I have little faith in it myself, it will be certainly interesting to watch its future.

The Brussels to Antwerp express line, which has been approved by the Belgian Government, is also on the Behr mono-rail system, but it is at present in abeyance, owing I believe, to want of financial support.

Another type of mono-rail electric railway for fast traffic, invented to keep the car on the road on sharp curves, is that called the Boynton bicycle road. It has been sucessfully experimented on in Long Island, New York. This has one rail at ground level, and a horizontal double-headed one in same plane above the car, supported by posts and brackets. Against this upper double-headed rail, two sets of horizontal flangeless wheels mounted on top of the car press, the weight of the car, of course being taken, by means of double flanged central wheels, set tandem fashion, by the central rail below. The upper rail serves as feeder and lower one as the return. It would appear as if this would havelessobjectionable featuresthan the Behr system, but the gauge between upper and lower rail would have to be very carefully maintained, or the car would slip out between them.

The Berlin Sozzen line is an existing one of 4 ft. 8½ in. gauge, of about 20 miles in length, nearly straight, which has been specially strengthened for experimental purposes. This has been ordered by the Emperor of Germany who is a good mechanic and electrician himself, as I was told by one of the leading engineers in Berlin in connexion with this project. One hundred and forty miles per hour is aimed at in these experiments, which had not come off when I was in Berlin last year, but I understand that 105 has been since attained. The Allgemeine Elekricitäts Gesellschaft are supplying, from one of their central stations, triphase currents of 10,000 to 12,000 volts in 75 periods, while Messrs. Siemens and Halske have constructed the overhead feeders. There are three wires one mitre

apart, and the current is taken up by three pairs of contact bars, one pair to each wire, and conveyed to transformers in the centre of the car, where it is reduced to a suitable voltage. This arrangement was considered as experimental only, as an alternative proposal was under consideration by which the transformers will be placed at substations.

Siemens and Halske and the Allgemeine Gesellschaft have each constructed a car, in friendly rivalry. That constructed by the former is 72 feet long, weighing 90 tons, with 50 passengers; it has a controlling compartment at each end, and is reversible. There are two bogies of three axles each, and the four motors can exert in all 3,000 HP. as a maximum. The other car is slightly shorter, 68 feet 10 inches, and lighter, 85 tons, but has the same passenger capacity. The transforming machinery is in the middle, and the driver at the front, both passengers and driver being entirely clear of possible contact with the current distributing details. There are three axles to each of the two bogies, the outside axles being inside the hollow shafting bearing the four motors which are directly connected with the driving wheels by springs, so that the concussion caused by axle borne motors is avoided. The motors are of 250 HP. normal and 750 HP. maximum power, as in the rival car, and this which will be required for a speed of 140 miles per hour, will involve a rate of revolution in the motor of as much as 960 per minute.

It will be seen that the proportion of dead to gross weight is much greater, in these cars, than in the monorail ones described, due chiefly to the extra weight of the transformers etc. carried in the Berlin cars.

In order to test the working of the car, at the great speed proposed, before actual trial on the rails, an ingenious apparatus was devised. The car was lifted so that each of its eight drivers rested upon a pair of cast steel rollers,

the tyres of which were shaped like the top table of the rail. The 16 rollers, which were mounted on a strong frame, were free to revolve at any speed. In this way the motors could be driven at full speed in the workshop, with the desired frictional resistance of the rails, represented by the rollers, but without any motion in the car itself.

To move each passenger at the rate of 140 miles per hour, as proposed by this scheme, will absorb 60 HP., an enormous increase on that expended in conveying one passenger that distance at ordinary express speeds, at the present time. Though there may be some economy in the production of a HP. through electrical means, it is very doubtful if there is a sufficiently numerous class of the travelling public, whose time would be so valuable as to justify them paying for such an expensive luxury. It is probable therefore that, unless supported by Government subsidy, the Berlin trials will have no effect beyond the record of an interesting experiment.

The new London to Brighton express electric line now before Parliament, is to be an ordinary bi-rail one. The present express service occupies 1 hour and 10 minutes in running 46 miles. By the new line, it is proposed to have a half-hourly service of 32 minutes. Unlike the Manchester and Liverpool however, there will be at least one stoppage on the route which gives, to some extent, a risk of accident. Heavy viaducts nearly 7 miles in total length, and 14 tunnels, having an aggregate length of 19½ miles, one of them being 7½ miles, are necessary for the purpose of avoiding sharp curvature, valuable property, and various obstructions. Hence, though the comparatively moderate through speed of 86 miles per hour will not require such costly power per passenger, as in the Berlin line, the interest on capital will be so high that the expectation of the promoters as to patronage must be very great. The present

gross value of the passenger traffic is said to be £170,000 per annum, or £550 per day.

The Vienna – Buda-Pesth line, which was proposed as a bi-rail express line, is in abeyance at present. But the most ambitious proposal of this kind was made, about five years ago, by Messrs. Davis and Williamson, for connecting New York with its four millions of people, with Philadelphia with one and a half millions, by an electric bi-railway 85 miles long. The maximum grade was to be 1 in 500 except the retardation ones at ends; sharpest curve 4 miles radius, with a superelevation of 3½ in. Car 150 tons, holding 140 passengers, 120 ft. between centre of 6 wheel bogies. Maximum speed 170 miles per hour or 250 feet per second, which means a revolution of the 7 ft. wheels of 680 per minute. Acceleration to full speed was to take 6 minutes at 0·70 feet per second per second, covering 8½ miles, and requiring the maximum power of 1,450 HP. per car. Retardation 3 feet per second per second, operating to full stop in 2 miles. A number of details including braking, signalling, permanent way and the electrical equipment, are given in the Engineering Magazine of October 1897.

Various proposals have been made towards a stable permanent way, other than those mentioned, for such high speeds as those contemplated. In the Vienna City Railway where, however, ease of motion at ordinary speeds is the principal object, the rail joints are fished, on the outside, with short lengths of the rails themselves, the space between the two webs being occupied by a filling piece. The inside member of the joint is an ordinary angle fish plate, the whole extending over the joint sleepers. The International Railway Congress have had proposals before them of a somewhat similar nature, the outer fish plate being so formed that its top is flush with the top table of the rail, thus adding to the mean depth of the ordinary

joint. With the exception of the case of the joint, there does not appear to be any proposition to alter the general form of the permanent way. Extra stability is only looked for by increasing weight.

As regards actual speeds, and the possibilities of largely increasing them on existing lines, by steam locomotion, the limitations in the United Kingdom have been mentioned. On the Continent, and in America, where the distances are greater, there is greater scope. In the former what are called International Expresses are now run, once or twice a week, from Paris to St. Petersburg and Moscow, Calais to Brindisi, Paris to Constantinople, etc., etc., which are simply moving hotels, from which the passengers need not alight during transit across Europe. Here, of course, the highest possible speed is a desideratum. In America, the cost of altering existing dimensions of bridges, etc., to enable more powerful locomotives to be used, is comparatively small.

As to actual everyday travelling express speed in these countries at present, I find that in the Northern Railway of France, the afternoon express from Paris to St. Quintin covers 95 miles in from 94 to 97 minutes, with trains of over 300 tons, and ruling grades of 1 in 200, 75 miles per hour being daily attained on this run on the down grades. Similar intermediate speeds are reached daily on several other lines in France and England, as I experienced myself on my recent trip.

The Pennsylvania railway in the States gives some of the best practice there, and records of the ordinary average fast train times between stations were taken between July and September 1901, on various sections varying from 15 up to 53 miles in length. The speeds range from 76 up to a maximum of as much as 89 miles per hour, the latter being reached on a 16 mile length by a train consisting of 9 cars.

Though English averages are not so fast as this, the ease of running at very high speeds is much greater than elsewhere. All the ordinary requirements of life, such as reading, writing, eating, sleeping, dressing, and even shaving, can be done, without the slightest discomfort, on the numerous express trains from London to the North, at velocities so great that the names of stations passed by cannot be distinguished, and the sleeping arrangements are so complete that each traveller has a cabin or room and toilet arrangements to himself. All this, of course, means weight, which is inseparable from the comforts and necessities of long distance travel, so that it cannot be compared with the single car trains of the Manchester and Liverpool, Berlin, and other short lines which do not want them.

The question of travelling at over 100 miles per hour, as now contemplated on the electric express lines, if applied to long distance trains, opens up the question of the human endurance sufficient to stand for many hours, the vibration and concussion involved, for there must necessarily be a great difference between these in that case, and what we are now called upon to sustain. If 400 miles are covered in 4 hours, and the traveller requires 4 hours additional to rest from the effects, nothing is gained. It is greatly a matter of training. Samson of old was a mighty man of valour, but if he could be resuscitated, and if he made a journey even in one of what are humorously called express trains in the Colonies, he would not only be frightened out of his wits, but greatly fatigued. The maximum speed between stations in the Colonies for many years past hardly reaches 40 miles per hour. For more than this there seems to be no public demand.

The conclusions which may be arrived at from the facts given in this paper, is that increase of railway passenger speed will be very gradual, and that the facilities afforded in this direction by electricity will not stimulate it much, except in the cases of short lines between such populous and wealthy centres as are to be found in the older countries.

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